National

SEALED LEAD-ACID BATTERIES TECHNICAL HANDBOOK

LCR Series

just slightly ahead of our time

INDEX

1. General Information

1.1 General Features

The LCR-Battery is a new type of sealed lead-acid rechargeable battery system developed by Matsushita Battery Industrial Co., Ltd. The lead-calcium rechargeable (LCR) battery, will stand up to tough operating conditions such as overcharge and deep discharge. In field service, troubles due to abnormal, improper operation or misuse are reduced to a minimum.
This section highlights the major features of the LCR battery.

1.1.1 High Quality & High Reliability

The LCR battery has stable and reliable capacity. It can be easily maintained to permit proper operation of the equipment that it powers. The battery withstands overcharge, overdischarge, vibration and shock,more readily than competitive products, and is capable of extended storage. To assure this high quality and reliability, **LCR batteries are 100% tested on line for voltage, capacity, and seals. And all vents are 100% visually inspected during the final assembly process.**

1.1.2 High Power Density

Through accumulated experience in high technology products such as VTR's, computers, and electronic equipment, National has acquired the knowledge needed for developing and manufacturing batteries with high power density.
These batteries save installation space, while providing full and reliable power for the equipment, and many have been designed for rapid recharge, or for high power output.
As a result, this power is used for applications ranging from VTR's to vacuums, electric tools, engine-start, UPS systems and computers.

1.1.3 Quick Chargeability

Where rapid recharge is required for portable devices such as tools, computers or medical equipment, high charge rate batteries (designated LCS) are available. Coupled with the proper charger, recharge in 1—1.5 hours is readily achieved.

1.2 Features of LCR Battery

1.2.1 Leakproof design.

The LCR battery uses an absorbed electrolyte system. All of the eletrolyte is absorbed into the positive and negative plates, and the separator material. Coupled with the use of special sealing epoxies, tongue and groove case and cover construction, and long-sealing paths for posts and connectors, the LCR batteries have exceptional leak resistance, **and can be used in any position**.

1.2.2 Long service life; float or cyclic.

The LCR battery has long life in float or cyclic service. **The expected service life is shown on page 9.**

1.2.3 Maintenance-free operation.

There is no need to check the specific gravity of the electrolyte or to add water during the service life.
The LCR battery is totally sealed, and needs only charging for maintenance.

1.2.4 No corrosive gas generation.

There is no corrosive gas generation during normal use.

1.2.5 Exceptional deep discharge recovery.

LCR batteries have exceptional deep discharge recovery and charge acceptance, even after deep or prolonged discharge, as illustrated in Figure A.

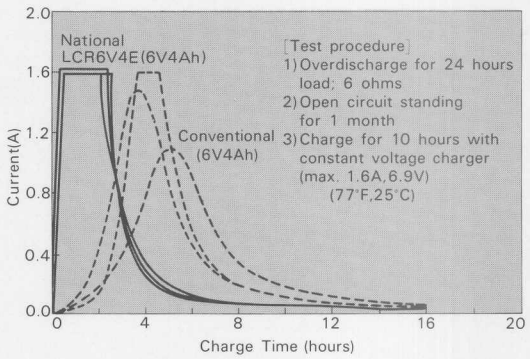


Figure A
Rechargeability after a Long Time Standing in Overdischarged State

1.2.6 DOT & IATA approval

The LCR batteries are considered as safe as dry cells, and have been approved for shipment by air by both DOT and IATA.

1.2.7 U.L. Component Recognition

U.L. Component Recognition under UL924, Section 38, for Emergency Lights and Power Supplier (not UPS), requires that the battery safely vent when over-charged, and tested under mineral oil. It further requires that the equipment and battery be submitted together for formal UL approval. **(UL Component Recognition does NOT remove this requirement for complete package testing)**.

Many National batteries have already passed this vent test are used extensively in emergency lighting and related applications. As of this writing, they are undergoing final UL Component Recognition testing, and completion is expected by July 1985 or sooner.

For assistance with UL requirements for your specific application, please contact National headquarters.

1.3 Applications

1.3.1 For Cyclic Use

Consumer Applications
Portable VTR/VCR, TV, record players, tape recorders, vacuum cleaners and appliances, and as portable power supplies.

Communication and Telephone Equipment
Cordless and portable telephones, tranceivers.

Office Equipment
Portable calculators, computers, electronic cash-registers, printers, typewriters.

Tools and Engine-start
Grass and hedge trimmers, cordless drills, screw-drivers, engine-start, and electric saws.

Instrument and Medical Equipment
Electronic instruments, measuring equipment, medical electronics, heart defibrillators.

Photography
Electronic cameras, strobe, VTR and movie lights.

Toys and Hobby
Radio-controllers, motor driving, lights.

1.3.2 For Trickle or Float Charge Use

Emergency Devices
Lights, fire and burglar alarms, communication systems, fire shutters.

Memory Back up
UPS systems, electronic cash registers, computers, sequencers, memory-chips.

1.4 Construction

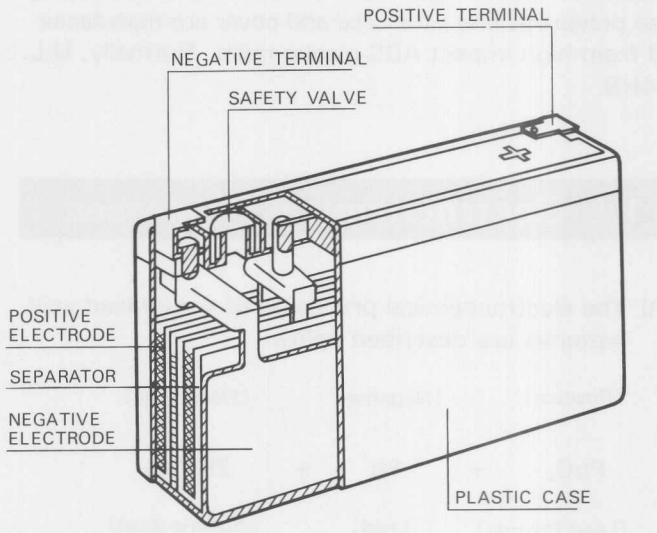


Figure 1
LCR-Typical "Absorbed Electrolyte" Battery

1.4.1 Positive Plates

Positive plates are made from a Lead-Calcium system.

1.4.2 Negative Plates

Negative plates are made from a Lead-Calcium system.

1.4.3 Separators

The glass fiber separators in LCR batteries have high resistance to acid, and low electro-conductivity.
The high porosity of the separators retains adequate electrolyte for the reaction of active materials in the plates.

1.4.4 Resealable Safety Vents

The venting system, which operates at 1 psi to 6 psi, is designed to release excess gas and keep the internal pressure within the optimum range of safety, while it protects the negative plates from contamination from oxygen in the air. **Vents are 100% visually inspected during production**.

1.4.5 Terminals

Depending on the battery model, the terminals may be Amp Faston Type 187, 250 or bolt and nut.
Excellent terminal sealing construction has been achieved by using long mechanical sealing paths and the selection of small shrinkage ratios for the sealing materials.

1.4.6 Case Materials

Unless otherwise specified, (some larger sizes may use polypropylene.) the case and cover are manufactured from high impact ABS plastic resin. Normally, U.L. 94HB.

1.5 Electrochemical Processes

(A) The electrochemical processes of sealed lead acid batteries are described below.

〔Positive〕 〔Negative〕 〔Electrolyte〕

$PbO_2 + Pb + 2H_2SO_4$

〔Lead Dioxide〕 〔Lead〕 〔Sulfuric Acid〕

$$\underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}}$$

$PbSO_4 + PbSO_4 + 2H_2O$

〔Lead Sulfate〕 〔Lead Sulfate〕 〔Water〕

In this process, charging and discharging are reversed with high efficiency, with the electrical energy used during discharge being regained during recharge.

(B) In the final stage of charging, an oxygen-gas generation occurs at the positive:

〔Positive〕 $H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$ ·····(1)

〔Water〕 〔Oxygen〕 〔Hydro ions〕 〔Electrons〕

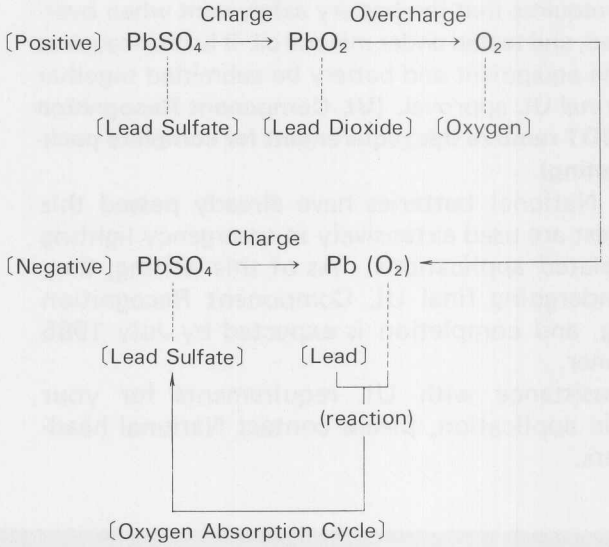
This oxygen converts to the open surface of the negative, after which an absorbing reaction occurs at the negative and absorption takes place.

〔Negative〕

$Pb + \frac{1}{2}O_2 + H_2SO_4 \rightarrow PbSO_4 + H_2O$ ·····(2)

〔Lead〕 〔Oxygen〕 〔Sulfuric Acid〕 〔Lead Sulfate〕 〔Water〕

The above gas generation and absorbing reactions can be expressed as follows.



Because the oxygen gas generated in the final stage of charging is absorbed by the negative, as shown by equations (1) and (2), there is no increase in internal pressure, despite the seald construction. When, however, the charging current exceeds the specified value, or when charging is conducted at less than the specified temperature, the amount of gas generated by reaction (1) cannot all be absorbed by reaction (2). In that event, an increase in internal pressure develops, and, in the worst case, the safety vent is activated.

(C) It should be noted that when the safety vent functions, electrolyte is consumed and performance deteriorates. To prevent or reduce this, it is important that charging should be conducted under recommended conditions.

1.6 General Characteristics

1.6.1 Charging

Charging method:

The batteries should be charged using a method selected from table 1. (**A detailed discussion of charging can be found in section 1.7**).

Table 1
Charging method & battery application

Application / Charging method	I Cyclic operation	II Trickle operation	III Float operation	IV Refresh charge during storage
Constant voltage	Regulation range of controlled voltage : 6 volt batteries : 7.3V to 7.5V 12 volt batteries : 14.6V to 15.0V Initial current : 0.4C or less. Short-time charge allowed.	Regulation range of controlled voltage : 6 volt batteries : 6.8V to 6.9V 12 volt batteries : 13.6V to 13.8V Initial current : 0.4C or less. This method can provide a short-time charge. Voltage must be regulated or battery may be overcharged or overdischarged.	Regulation range of controlled voltage : 6 volt batteries : 6.8V to 6.9V 12 volt batteries : 13.6V to 13.8V Initial current : 0.4C or less. Not allowed to use if current capacity of the charger is not big enough to maintain the specified charging voltage during float.	Regulation range of controlled voltage : 6 volt batteries : 7.3V to 7.5V 12 volt batteries : 14.6V to 15.0V Initial current : 0.4C or less. Short-time charge allowed. Several of the same model batteries, under the same storage, can be charged in series. Otherwise they should be recharged in separate groups.
Constant current	Charging current : approx : 0.1C. Charging time control is recommended because an overcharge is more likely to occur.	Not applicable	Not applicable	Charging current : approx. 0.1C. Charging time control is recommended because an overcharge is more likely to occur.
Combination		Two-step charge : Charging current : approx. 0.4C at the first step. 0.0002C to 0.0005C at the second step. A time control or a charging voltage detection device is required to transfer from the first step to the second.		

(Note: all at 20°C, 68°F)

Please contact National for further information.

Note : C rates in the table refer to current as a percentage of rated capacity.

Example: for model LCR-306E (3.2Ah),
0.4C = 0.4 × 3.2 = 1.28 amps.

1.6.1.1 Charging-Temperature Compensation

It is recommended that the charge voltage be adjusted to compensate for the battery temperature as shown below. If desired, this may be done by detecting the ambient temperature near the battery instead of the battery temperature. (**also see Section 1.7.5.1**)

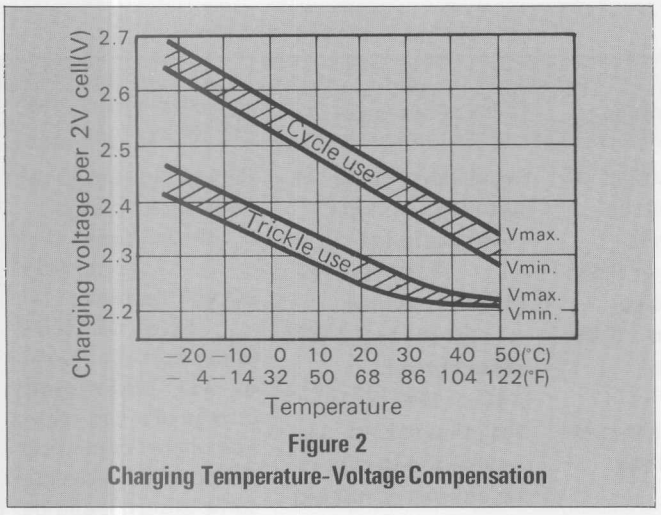


Figure 2
Charging Temperature-Voltage Compensation

1.6.1.2 Constant Voltage Charger-Characteristics

The graph below shows the output V-I characteristics of the recommended charger.

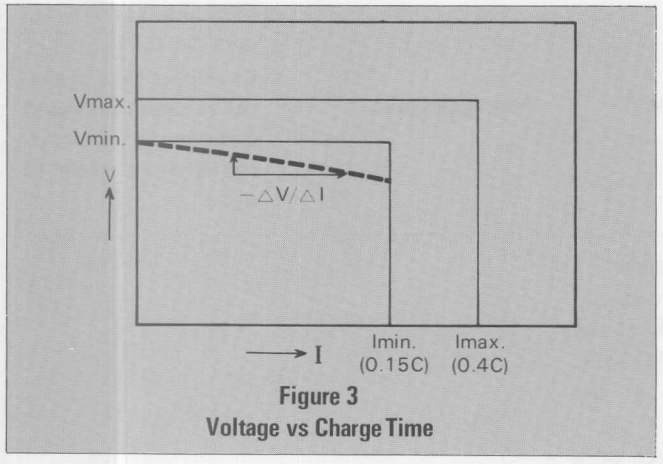


Figure 3
Voltage vs Charge Time

V (preset voltage): an output voltage that is preset at current

$$\text{of } \frac{1}{100} \text{ C.}$$

$-\triangle V/\triangle I$ (Voltage stability): the larger this absolute value, the longer the charging time becomes, even with the same preset voltage.

1.6.1.3 End of Charge

The time required to complete each charge depends on the discharged condition of battery, characteristics of charger used, or the temperature during charge.

This time can be estimated by the following expression for cyclic use:

$$Tch = \frac{Cdis}{I} + 3 \sim 5$$

Tch: time required for charge (hours)
Cdis: ampere-hour discharged before charge started
I: Initial current

Complete charge time for trickle service will be slightly more than 24 hours.

1.6.1.4 Charging Temperature

1. The battery should be charged at an ambient temperature within the range of 0° to 40°C (32° to 104°F).
2. The most effective charging temperature range is 30° to 40°C (50° to 86°F).
3. Charging at temperatures below 0°C (32°F) or over 40°C (104°F) is not recommended; the battery might be deformed by heat, or not charged enough.
4. **See 1.6.1.1 for temperature compensation.**

1.6.1.5 Reverse Charging

Do not charge in reverse. Reverse charging will damage the battery or charger circuitry.

1.6.1.6 Overcharging

Any extra charge after the battery is fully charged, is called overcharge. Continued overcharge shortens the battery life. Select the charge particularly specified or approved for each application.

1.6.1.7 Charge before Use

It is recommended that batteries should be charged before use to compensate for normal capacity loss during storage. See column Ⅳ, page 6; or para. 1.7.1, page 10.

1.6.2 Discharging

1.6.2.1 Battery Selection

1. Select operating current.
2. Select operating run time.
3. Determine the closest **amp-hour** capacity to meet requirement. **(Ampere-Hour Selection Chart, page 21).**
4. Use the Battery Index on page 20 to select the closest battery voltage, size and weight to meet application requirements.
5. Example: 2.9Amps, 1.5 hours
   12 volts
   Space: 100mm x 160 mm x 105mm High
   Selection: 6.5AH
   LCR 12V6.5 (94 mm x 151mm x 100mm)
6. **Detailed curves and dimensions can be found for each individual battery, on data sheets in Section 3.**

1.6.2.2 Discharge current rates and recommended cut-off voltage

Figure 4 gives recommended cut-off voltages for 6V or 12V batteries, consistent with discharge rates. [Note; In some applications, a specific cutoff voltage may be required by local or national codes. For example, emergency lighting normally requires a cutoff of 1.75V/cell on a lead-acid battery (5.25V or 10.5V).]

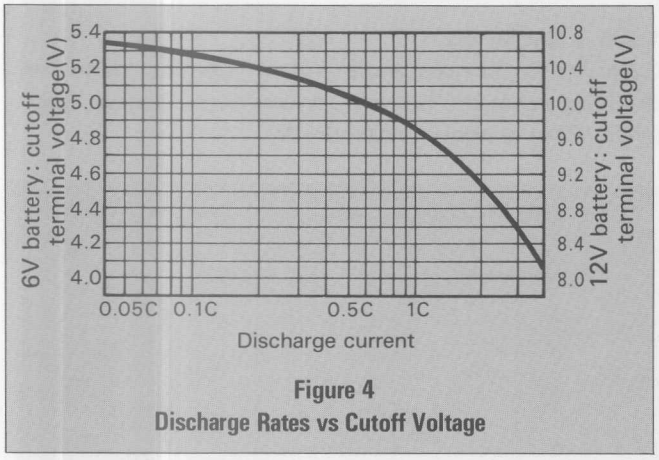


Figure 4
Discharge Rates vs Cutoff Voltage

1.6.2.3 Discharge temperature

1. The ambient temperature during discharge should be held within the range of −15° to 50°C (5° to 122°F).
2. Low temperature (below −15°C, 5°F) may reduce the available capacity; and high temperature (over 50°C, 122°F) may bring about thermal run-away and damage the battery.

1.6.2.4 Effect of temperature upon performance

The available capacity is affected by both temperature and discharge current as shown in **Figure 5.**

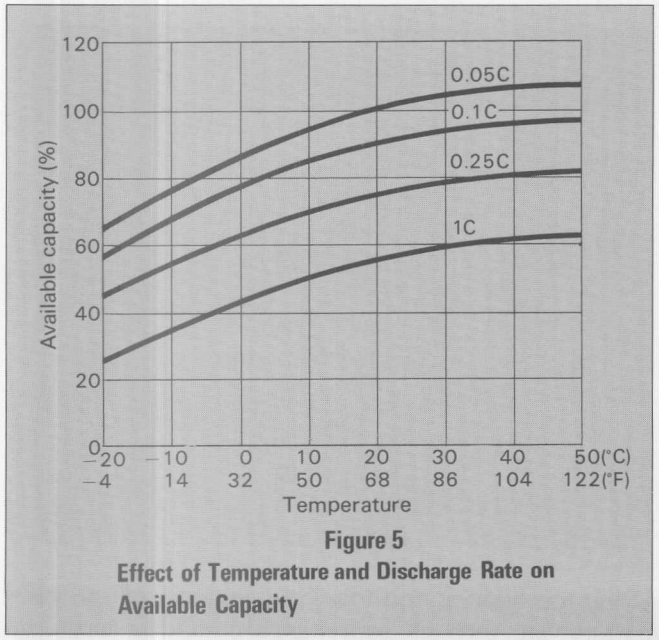


Figure 5
Effect of Temperature and Discharge Rate on Available Capacity

1.6.2.5 Discharge current

For best efficiency, discharge within the range of 0.1C to 2C. Higher rates are allowed as published. For special assistance, contact National.

1.6.2.6 Deep discharge

Although National LCR batteries have unusually excellent deep discharge recovery capability, if the batteries are repeatedly discharged below specified cutoff voltage, battery life is shortened.

1.6.3 Storage

1.6.3.1 General storage conditions

The battery should be stored under the following conditions.

1. Low humidity
2. −15° to 40°C (5° to 104°F)
3. Clean, and out of direct sunlight

1.6.3.2 Capacity after long term storage

After long term storage, all batteries deliver less than rated capacity on first cycle. In cyclic application full capacity will be obtained through several charge/discharge cycles.

In float application, full capacity will be achieved with in 24-48 hours, when charged at 2.3V/cell.

1.6.3.3 Refresh charge

When batteries are in extended storage, it is recommended that they receive a refresh charge at recommended intervals;

Storage ambient	Recharge interval
below 20°C (68°F)	18 months
20° to 30°C (68° to 86°F)	12 months
30° to 40°C (86° to 104°F)	6 months

1.6.3.4 "Shelf Life" — capacity vs time

Self-discharge rate is very much dependent on the storage temperature as shown in **Figure 6.** Lower temperatures allow the battery to be stored for longer periods. (Each ten degree centigrade drop results in a halfing of self-discharge rate and doubles storage time.)

1.6.3.5 "Shelf Life" — Storage time vs temperature

Figure 7 shows the time for the capacity to decrease to 50% of nominal capacity at each temperature during storage. If the storage temperature is known, the graph may be used for finding the most useful recharge intervals.

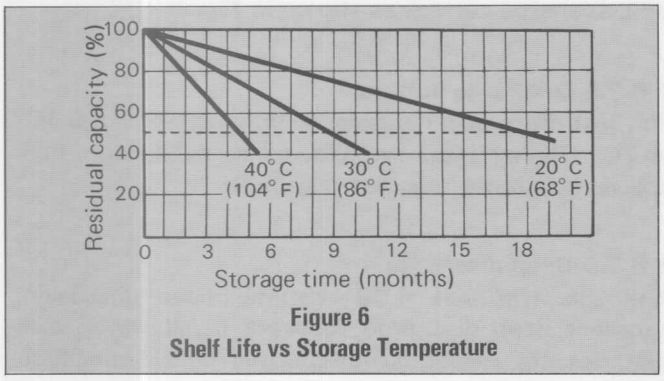


Figure 6
Shelf Life vs Storage Temperature

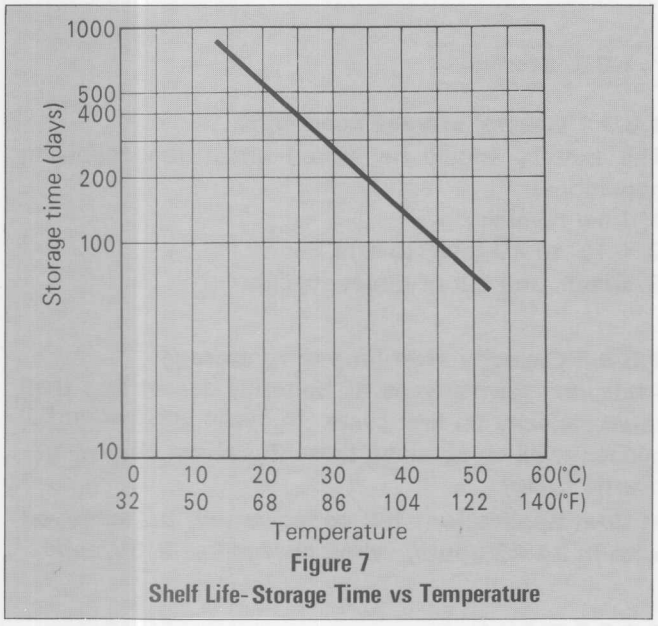


Figure 7
Shelf Life-Storage Time vs Temperature

1.6.3.6 Open circuit voltage & Residual capacity

Residual capacity can be estimated by measuring the open circuit voltage as shown in Figure 8.

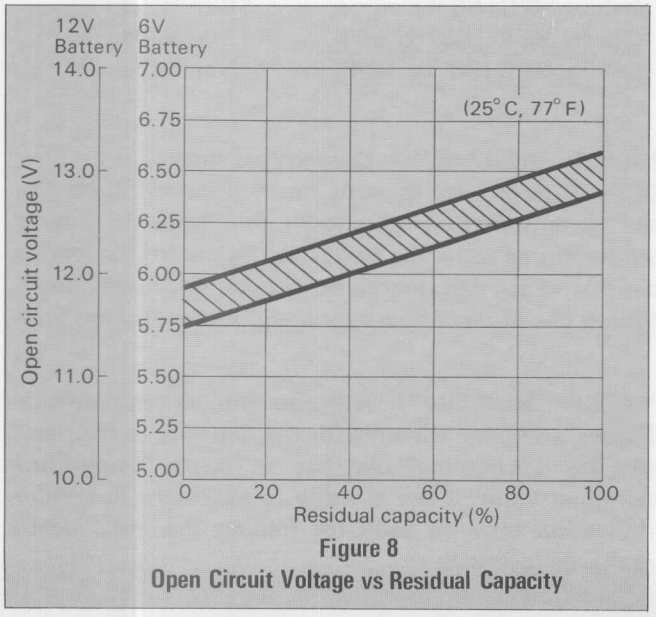


Figure 8
Open Circuit Voltage vs Residual Capacity

1.6.4 Temperature Range Summary

Discharge:	−15°~50°C	5°~122°F
Charge:	0°~40°C	32°~104°F
Storage:	−15°~40°C	5°~104°F

1.6.5 Battery Life

1.6.5.1 Cyclic life

Cyclic life is very much dependent on the depth of discharge that the battery encounters during each cycle. This is shown in Figure 9.

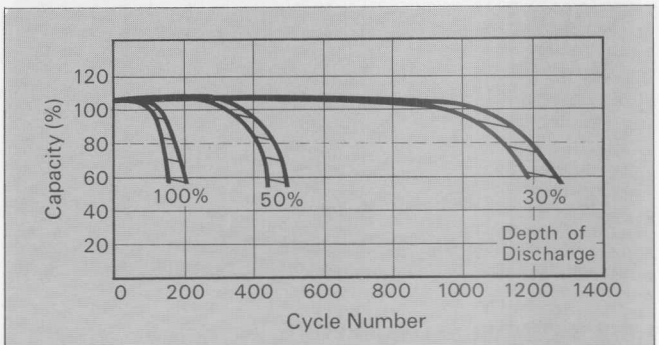


Figure 9
Cyclic Life vs Depth of Discharge

Note: A battery has reached its expected life, when it fails to deliver 80% of it's originally rated capacity.

1.6.5.2 Float or Back up Life

The expected float life at room temperature is approximately 8 years on the basis of accelerated tests. This is shown in Figure 10, based on 2.30V/cell.

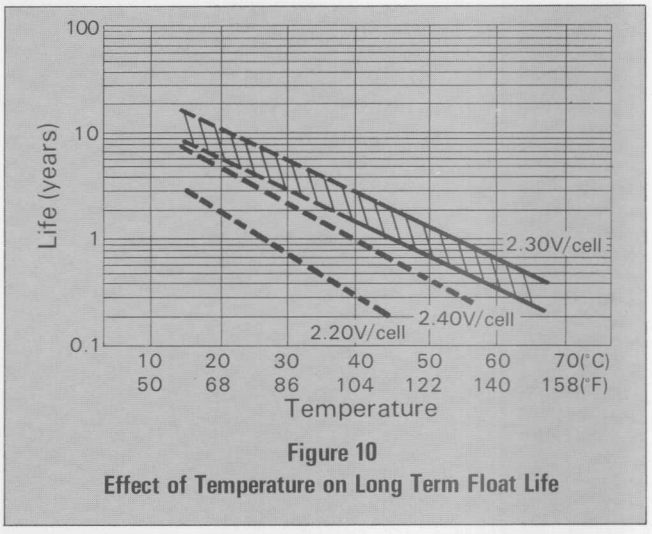


Figure 10
Effect of Temperature on Long Term Float Life

Using too high or too low float voltage will shorten battery life, through overcharge or undercharge, as indicated by lines A and B in Figure 10.

1.7 Charging Methods

In brief, charging is the process of supplying direct current to the battery so as to convert it back into a chemical state at high energy level, capable of delivering electric power.

There are a variety of charging methods which can be used to charge sealed lead-acid batteries. From the view point of controlling the charging process, these methods can be classified into some basic categories: **constant-voltage, constant-current, tapered-current** and **combination charge systems.** (There are some other special methods used to control the charge by detecting internal pressure or battery temperature.)

The above types (with the exception of the special methods) are discussed here: 〔a summary chart appears in section 1.6.1〕

1.7.1 Constant Current Charger

Constant current charging is one of the most well-known methods.

The advantage of constant current charging is the ease of determining the amount of current (amp hrs) supplied during charging; and there is no need for temperature compensation which is required in constant voltage systems.

On the other hand, the required charging time should be strictly adhered to, especially at high currents which provides a full charge in a short period. On high-rate charge, the battery voltage rises excessively and the water decomposes,, accompanying heat generation at the final stage of charge. This can damage a battery.

The constant current method, however, may be satisfactory when the charge rate can be kept at a relatively low rate and charging time is not critical.

Because of self-discharge, batteries require a refreshing charge from time to time during storage. A constant current charge may be used as a refreshing charge when many batteries are charged at one time, as this method will easily determine the amount of charge returned to the battery. **Batteries, which have been left on the shelf under the same known condition, shall be recharged approximately 120 percent of the lost capacity (Ah), as estimated from the data on ''Shelf Life''.**

If storage conditions such as temperature and time are known, but different for each battery, the charging amount shall be based on the worst storage condition or the largest lost capacity. For longest life, it is not recommended to repeatedly use constant current charging for refreshing the batteries.

It is also important to minimize the need to repeat the refreshing charge,by always keeping the batteries under a well-controlled stock rotation plan. *Storing at lower temperature is the key to battery shelf life. If stored at a high temperature, batteries will require frequent refreshing charges.*

1.7.2 Constant Voltage Charger

It is very often necessary to restore batteries to a fully charged condition in as short a time period as practical. In doing this, much care must be exercised not to exceed specified charge rates or charge voltages as the battery is approaching a fully charged condition. A constant voltage charger can accomplish this type of charging. Ideally such a charger should have very stable output voltage and high current capacity, as extremely large currents are allowed to flow at the initial stage of charge, where the battery voltage is low. This type of charger, however, is not practical because the requirement of a high current capacity, or a negligible small impedance for the power transformer, results in high cost and a large and heavy charger. Undesirable heat generation inside the battery cells,caused by initial high current, should also be taken into consideration.

In general, a commonly utillized constant voltage charger has a device to limit initial current. This current limitation can be accomplished by a constant-current regulator, a properly designed output voltage from the power transformer, or by designing the overall impedance of the circuit (for example by using a current regulating resistor). A constant voltage charger will perform effectively for charging in a short time, as during the final stage of charge the current automatically decreases, and the water decomposition will be minimized.

1.7.3 Tapered Current Charger

This is a simple and relatively inexpensive method. The circuit requires a power transformer, rectifiers and a suitable resistance for limiting current. In this system, the charging current drops gradually as the charging proceeds. If the impedance of the circuit is low, a step current slope can be obtained. This type for charge is generally considered to be unsuitable for charging sealed lead-acid batteries because the charging current will vary with fluctuation of line voltage as well as changes in battery voltage.

These effects, however, can be minimized by using a power transformer with a secondary voltage which is considerably higher than the battery voltage and a suitably high resistance in the circuit for current limiting. This type of charger will perform similar to a constant current charger, and can be utilized instead of a constant current charger for industrial uses; not only for recharging many batteries at one time, but also as a tricke charging system.

1.7.4 Combination Charger (Two-step)

A combination charger employs two types of charger. It's called a "Two-rate" or "Two-step" charger. A variety of couples can be made, such as constant-current/constant current, constant-voltage/constant-current and so on. In general the first step uses a quick or fast charge mode, and the second uses a low charge current. The switching from the first step to the second can be carried out by many different methods; battery voltage sensing, a time control, charge current sensing etc. **Some of these typical charging patterns are shown in Figure 11.**

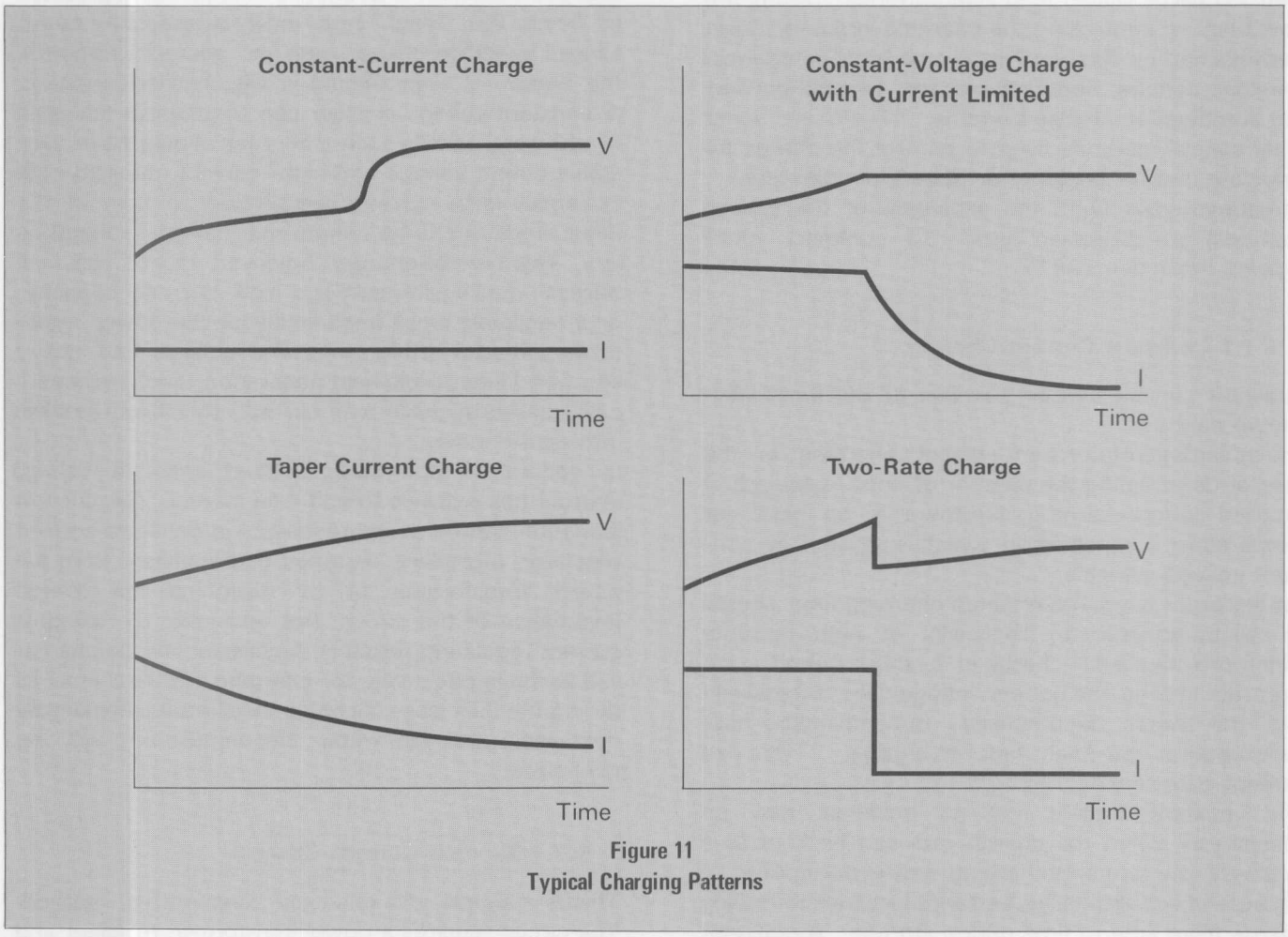


Figure 11
Typical Charging Patterns

1.7.5 Charging Application Notes

All of the charging methods discussed above are commonly used with satisfactory results. Applications of sealed lead-acid batteries can be classified roughly into two types; cyclic operation and standby service, and must be charged accordingly.

1.7.5.1 Cyclic Operation

Cyclic applications generally require a short time charge and protection against excessive charges and discharges, because the battery may be operated under unfavorable conditions by inexperienced users.
The most important requirements in a constant voltage charge technique are to hold the output voltage at the specified level at the final stage of charge, and to suppress the initial current below the designated maximum value as follows;

(1) Constant Voltage Charge:
Initial current: 0.4C or less
Regulated voltage: 7.3 to 7.5V/per 6V battery
(Note) C means the nominal capacity.
** The regulated voltages are at a temperature of 20°C (68°F)

For a 12V- or a 24V-battery, the regulated voltage (above) shall be multiplied by 2 or respectively.
If the battery will be charged in a wide range of

ambients, **it is desirable for the charger to be temperature-compensated as shown in Figure 12.**

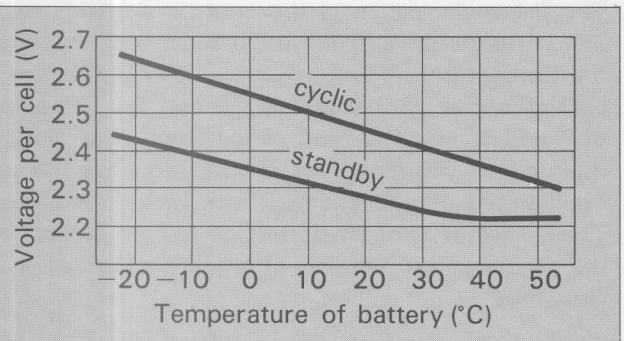


Figure 12
Recommended Temperature-Compensation for Voltage Regulation at the End of Charge (EOCV)

Without temperature compensation, the charge might be excessive in a high ambient area, insufficient in a low ambient area, resulting in cycle life patterns as illustrated in Figure 13.

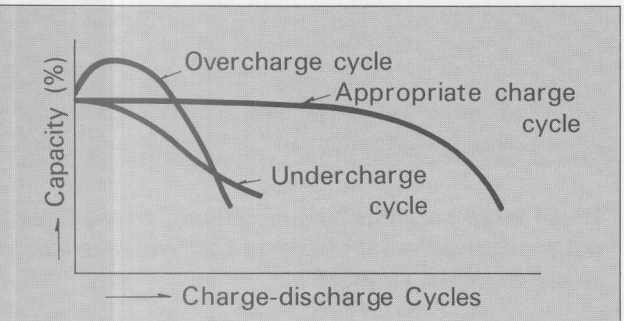


Figure 13
Cycle Life Patterns Resulting from Various Charging Conditions.

1.7.5.2 Standby/Backup Charging

LCR batteries (unless otherwise noted) can be utilized in standby applications, where they normally are kept in fully charged condition, and serve as a power supply to the load only when AC power fails. There are two modes of charging standby applications; trickle- and float-charge.

1.7.5.2.(a) Trickle Charge

This is a system in which AC power is normally supplied or operating the equipment, while charging the batteries which are not connected to the load. If AC power fails, a relay circuit connects the batteries to the load and battery power is supplied.

Trickle charging is generally considered to compensate for selfdischarge by continuously charging the battery at a low constant current to keep it fully charged. A constant voltage charge can accomplish this objective.

The appropriate current rate for trickle charge is 0.0002C to 0.0005C. (C/5000 fo C/2000)

In applications where AC power failure occurs infrequently, and the discharge is very small, the battery will be restored to a fully charged condition in short time, even at such a low current rate. In the case of deep discharges, this method will take an extremely long time to charge the battery. **A two-rate charger, or a constant voltage charger, is recommend for solving the problem, because of their initial quick charge modes. A two-rate charger has a distinct advantage, as there is no need for temperature-compensation.**

A constant voltage charger requires some precautions as follows:

(1) In these applications, the batteries are subjected to constant charging so long as a voltage difference exists between the battery and charger voltages. The charger voltage, therefore, must be stabilized in a narrow range during trickle charge.

(2) **When using the battery in a wide range of ambients, the charger should be temperature-compensated, as the charge characteristics will be greatly affected by the ambient temperature. (See Figure 12).**

Typical data for trickle charge application is shown in Figure 14.

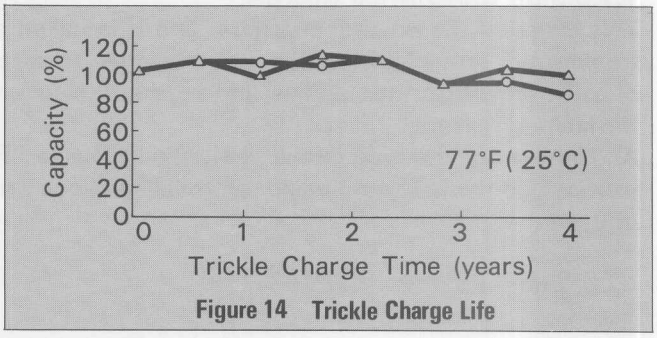


Figure 14 Trickle Charge Life

1.7.5.2.(b) Float Charge

This is a system in which the load and the battery are connected in parallel with the rectified power source.

This system requires only a constant voltage charger, in which the charge voltage is stabilized in a range of 6.8V to 6.9V per 6V battery, regardless of the power consumption by the load.

As the regulated voltage of a float charger is very close to the open circuit voltage of the battery, major fluctuations in the charge voltage may cause many small discharges of the battery while on float. In other words, the constant voltage charger should be designed for the maximum load, or the maximum load should be balanced within the stabilizing ability of the charger. Otherwise the life of the battery can not properly be estimated due to the irregular and complicated discharge

patterns. In general, life in float service may be somewhat shorter than in trickle charge service.

1.7.5.3 Charger Design

1.7.5.3.(a) General Considerations

Battery life is affected not only by performance of the charger, but also by operating conditions. Charger, selection and design, therefore, must consider battery usage as well as charging characteristics. All charger designs use the same fundamental principles and require knowledge of the following basic parameters.

(1) the internal resistance of the batteries,
(2) the initial and final charge current and/or voltage value,
(3) the charges in battery voltage during the charging process,
(4) the required charging time,
(5) the effect of variable conditions such as ambient temperature and changes in voltage on the battery parameters,
(6) the maximum overall cost for the charger and batteries, and
(7) the expected battery life.

It should be noted that the resistances of lead wires and wire connections may be higher than the internal resistance of the battery.

1.7.5.3.(b) Unregulated Charger

This is one of the simplest chargers, and it is called a transformer type charger. This type of charger consists of a power transformer, diodes, and a resistive element for limiting current.

An elementary charging circuit is shown in Figure 15 from which the following basic electrical relations are derived.

$$Edc = Eb + IR \qquad I = \frac{Edc - Eb}{R}$$

where Edc is an impressed voltage from a direct current power sourse, Eb is battery voltage during charge, I is a charging current, and R is an overall impedance in the circuit (which consists of the internal battery resistance, rectifier dynamic resistance, current limiting resistance,and impedance of power transformer).

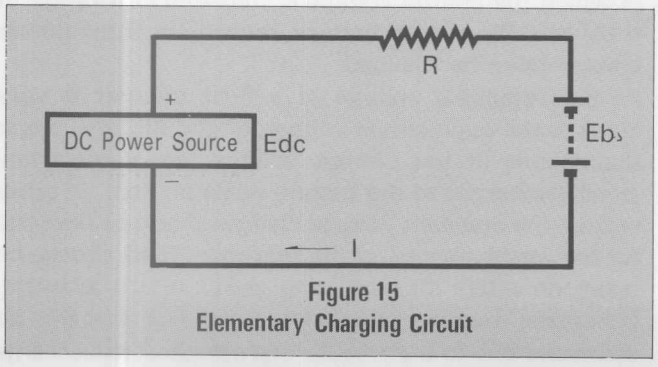


Figure 15
Elementary Charging Circuit

The DC voltage of the circuit decreases with increasing charge current due to the overall impedance. The V-I performance of the charger depends on the circuit resistance and the open the circuit voltage of the transformer. Figure 16 shows three different V-I performances by chargers P-, Q- and R-. The circuits of P and Q have the same impedance, but different open circuit voltages. P- and R-circuits have the same open circuit voltage, but their impedances are different. The V-I relations of the battery at various states, from the discharged to the fully charged condition are also illustrated.

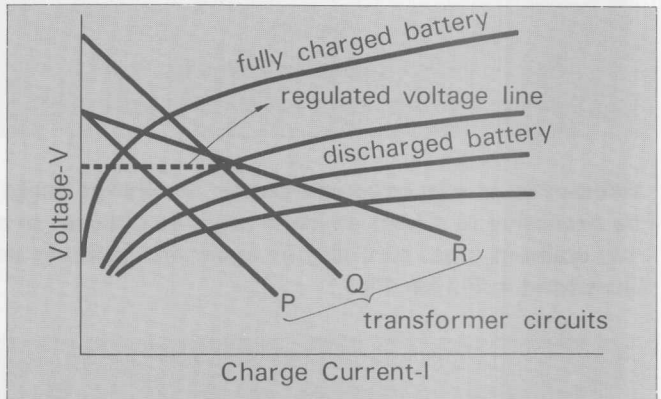


Figure 16
V-I Relations of Chargers and Battery at various states of charge

These three chargers having different V-I characteristics, will provide different charging performances as shown by solid lines in Figure 17.

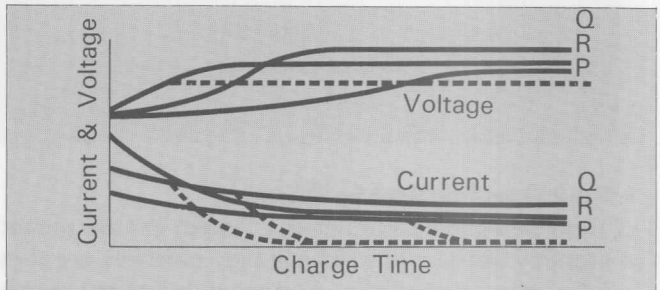
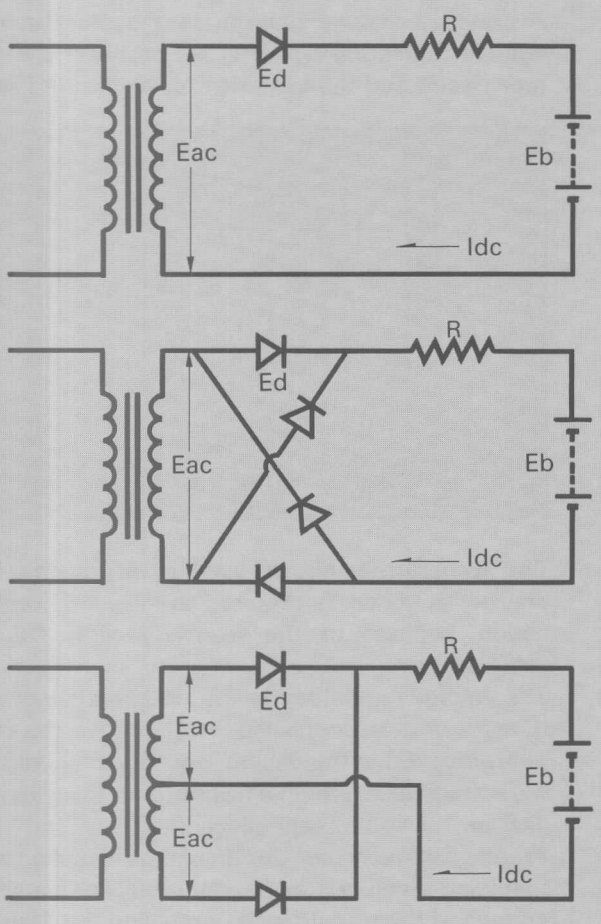


Figure 17
Charge Performances of P-, Q- and R- chargers having different V-I characteristics

The difference in V-I characteristics of the chargers results in different final steady state on charge voltages. However, if these circuits are connected to the batteries through a voltage regulating device, charge performance curves will reach the same final state. This constant voltage charger will be discussed in the next section. The single phase charging circuits and design equations are shown in Figure 18.



HALF-WAVE

$Eac = K_1 (Ed + Ed) + K_2 Idc \cdot R$

$Irms = K_3 \ Idc \ \sqrt{2}$

FULL-WAVE, BRIDGE

$Eac = K_1 (Ed + Ed) + \frac{K_2}{2} Idc \cdot R$

$Irms = K_3 \ Idc$

FULL-WAVE, CENTER TAP

$Eac = K_1 (Ed + Ed) + \frac{K_2}{2} Idc \cdot R$

$Irms = K_3 \ Idc$

Figure 18
Single Phase- Unregulated Charging Circuits and Design Equations

The symbols in Figure 18 are as follows:

Eac = Open circuit rms source (secondary) voltage
Eb = Battery voltage during overcharge
Ed = Rectifier forward threshold voltage
Idc = Average overcharge current
R = Total circuit resistance
K_1 = DC voltage equation factor (taken from Figure 19)
K_2 = DC current equation factor (taken from Figure 19)
K_3 = Current form factor (taken from Figure 19)

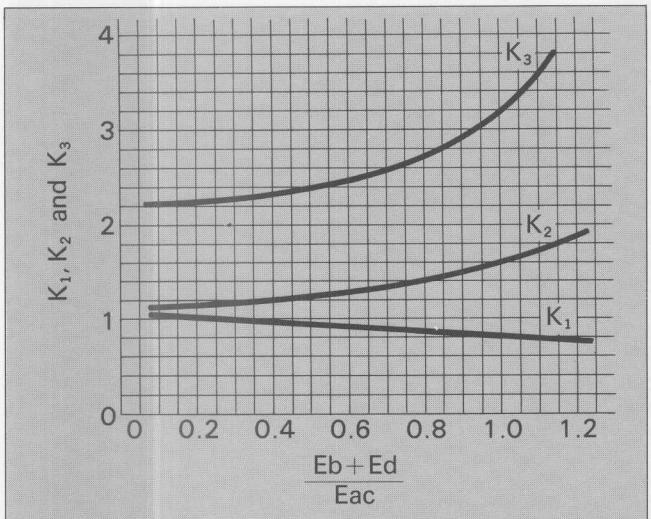


Figure 19
Design Equation Factors for Transformer Type Chargers

Charge currents at the 1-hour rate or less are commonly used in this type of charging system. Although the battery voltage during overcharge (Eb) varies with the charge rate and temperature, a value of 2.8 volts per cell is used with a satisfactory result for charger design calculations.

A smaller ratio of (Eb + Ed) to Eac requires higher resistance for current limiting, which results in higher power losses. However, this may minimize charge current changes with line voltage fluctuations. The ratio is commonly chosen to be between 0.4 and 0.7. The rectifier voltage drop (Ed) depends on diode materials and circuit types, as shown in the following Table.

Rectifier voltage drops (Ed)

Type of circuit	Materials Silicon
Half-wave	0.8V
Full-wave, Center tap	0.8V
Full-wave, Bridge	1.6V

Peak inverse voltage (PIV) applied to the diode is the sum of the AC peak voltage ($\sqrt{2}$ Eac) and the battery voltage (Eb) for half-wave and, full-wave bridge type rectifications, or $2\sqrt{2}$ Eac for full-wave center tap.

Half-wave rectification is more economical than full-wave, if the product of Irms and Eac is small. Otherwise it is advisable to shift to full-wave rectification.

1.7.5.3.(c) Constant Voltage Charger

A constant votage charger is a system in which a voltage regulating device is put between the transformer circuit and the batteries, as shown in Figure 20.

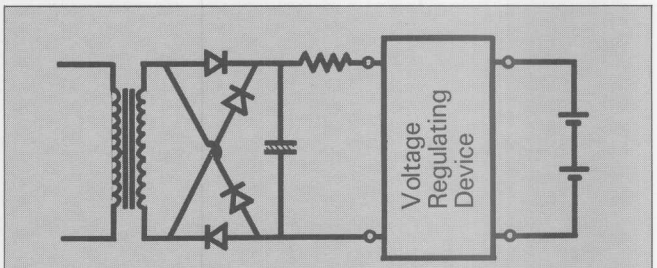


Figure 20
Charging Constant with Voltage Charger

The transformer circuit used in a constant voltage charger is generally required to have full-wave rectification, because of the relatively high DC current required.

The voltage regulating device includes a power transistor or thyristor to be connected in series with the batteries. Therefore, Ed in the design equations should include the voltage drop which a transistor or thyristor produces (0.8 or 1.1 volts, respectively).

Practical transformer design can be satisfied with the following rough calculation: the required rms secondary voltage of the transformer, supplying the desired initial current, is 3.5 to 4 volts in excess of the nominal voltage of the batteries. For example: to design a charger with an initial current of 1.0 ampere for a 12 volt battery, the transformer is required to have a secondary voltage of 15.5 (=12+3.5) volts when loaded at 1.0 ampere.

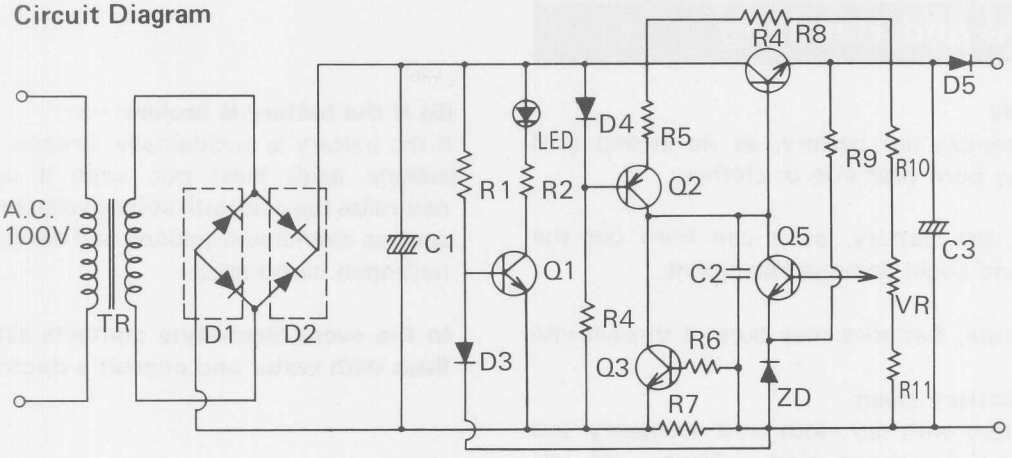
The voltage regulating device has a voltage detecting circuit which may allow a small current leakage from the batteries when AC line fails; and a diode for preventing reverse current flow may be put between the regulating device and the batteries, if necessary. In this case, however. the voltage drop caused by this diode should be included in the total diode voltage drop Ed. (It should be noted that the regulating device maintains a total potential equal to this diode plus the batteries, but does not apply a constant voltage to the batteries.)

In order to get a smooth current a filter capacitor is usually utilized. A big capacitance results in a large, well-smoothed current. But too big a capacitance may shorten life of the capacitor.

Characteristics of semi-conductors such as transistors diodes and Zener diodes, are all affected by temperature. Some have negative coefficients, and others positive ones. It is important to select semiconductors, and combine them, so that the voltage regulating device will have a temperature coefficient conforming to the battery characteristics.

A typical constant voltage charger and components are shown in Figure 21.

Circuit Diagram



Parts List		
Mark	Parts List	Remarks
TR	transformer	0.8 A 15.5 V
C3	condenser	25 V 47 μF
C2	condenser	50 V 10,000 PF
C1	condenser	50 V 470 μF
VR	resistance	500 Ω 0.1 W
R11	resistance	1.0 KΩ 1/4 W
R10	resistance	2.2 KΩ "
R9	resistance	1 KΩ "
R8	resistance	5.6 KΩ "
R7	resistance	1.2 Ω "
R6	resistance	56 Ω "
R5	resistance	56 Ω "
R4	resistance	5.6 KΩ "
R2	resistance	1.2 KΩ "
R1	resistance	33 KΩ "
ZD	diode	5 V 500 W
LED	diode	
D5	diode	1A 200 V
D4	diode	1.2 V
D3	diode	
D2	rectifier	2 A
D1	rectifier	2 A
Q5	transistor	NPN
Q4	transistor	NPN
Q3	transistor	NPN
Q2	transistor	PNP
Q1	transistor	NPN

Figure 21
Example of a Circuit with Voltage Regulation

1.8 Care and Handling

(1) Disassembly
Do not disassemble the battery, as its strong acid electrolyte may burn your skin or clothes.

(2) Shorting
Do not short the battery, as it can burn out the connections and could damage equipment.

(3) Disposing
Do not incinerate. Batteries may burst if thrown into fire.

(4) Keep the battery clean
Wipe the battery with dry cloth or, if necessary, use water or alcohol-dampened cloth. Never use oil, gasoline,thinner or other petrochemicals.

(5) If the battery is broken·····
If the battery is accidentally broken and electrolyte (sulfuric acid) leaks out, wipe it up with a cloth, neutralize the acid with some available alkaline substance such as ammonium solution and baking powder (sodium hydrogen carbonate).

In the event electrolyte contacts skin, immediately flush with water and consult a doctor.

2. Application and Selector Guide

This section is designed to make it easy to select the best battery for your application and space.
For additional assistance, please contact National.

2.1 Battery Design Guide

Application: _____

- Voltage
  - Nominal _____
  - Minimum (discharge) _____
  - Maximum (charge) _____

DISCHARGE CONDITIONS

- Current
  - Average _____
  - Peak _____
  - Minimum _____
- Time _____
  - Overall (Total) _____
  - At Peak _____
- Temperature
  - Average _____
  - Maximum _____
  - Minimum _____

CHARGE CONDITIONS

- Time _____
- Method
  - Cyclic Use _____
  - Stand-by Use _____
- Temperature
  - Maximum _____
  - Minimum _____

Dimesions

- Length _____
- Width _____
- Height _____
- Weight (desired) _____

SHELF LIFE

- Time _____
- Temperature
  - Maximum _____
  - Average _____
  - Minimum _____

Terminals

- Faston Tab.
  - Type 187 _____
  - Type 250 _____
- Bolt on _____
- Wire leads _____
  - Length _____
  - Gauge _____
  - UL # _____

2.2 Battery Selection

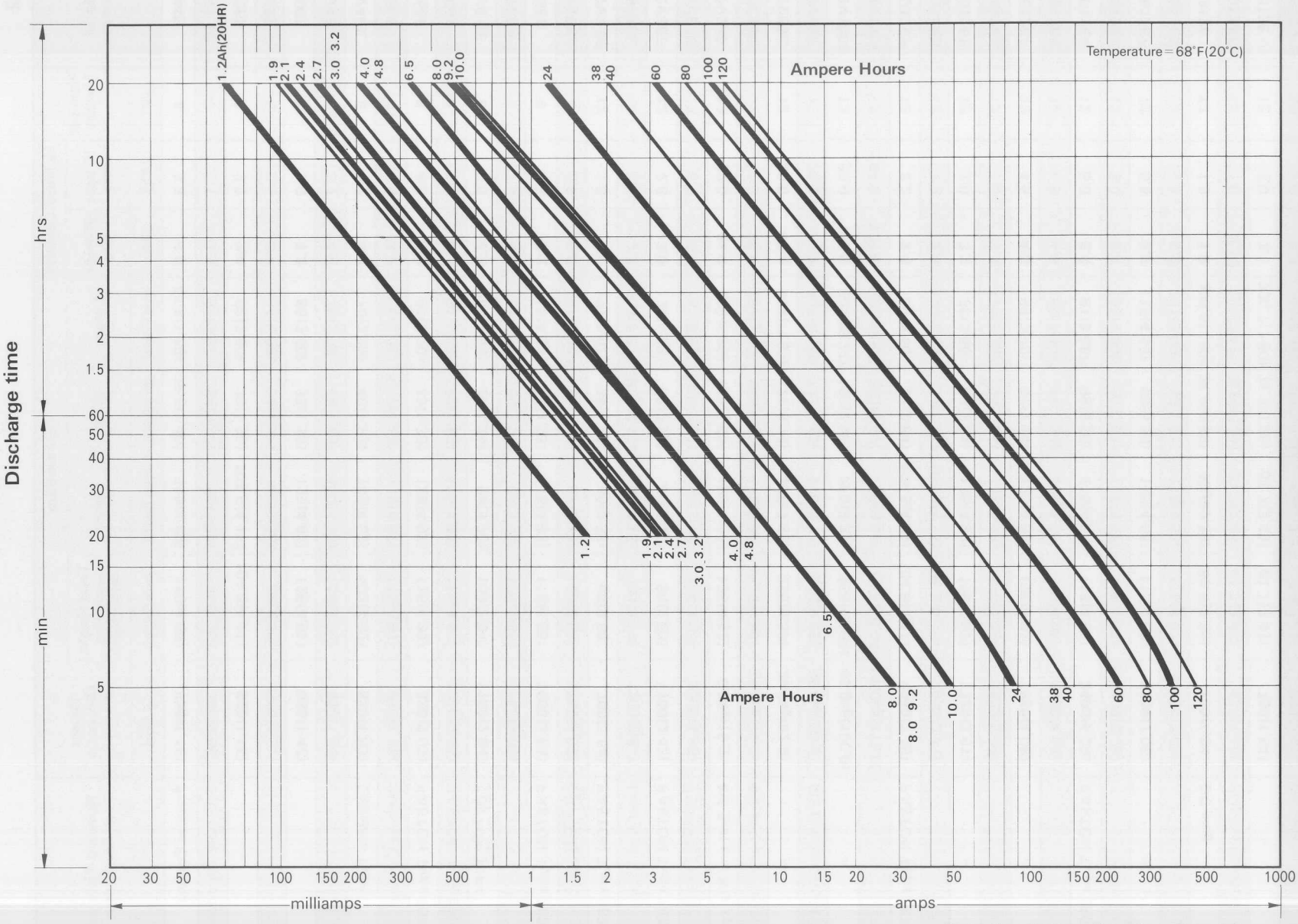
1. Select operating current.
2. Select operating run time.
3. Determine the closest amp-hour capacity to meet requirement. **(Ampere-Hour Selection Chart, page 21 〔section 2.4〕).**
4. Use the Battery index on page 20 to select the closest battery voltage, size and weight to meet application requirements.
5. Example: 2.9amps, 1.5hours
   12 volts
   Space: 100mm x 160mm x 105mm High
   Selection: 6.5 AH
   LCR12V6.5 (94mm x 151mm x 100mm)
6. **Detailed curves and dimensions can be found for each individual battery, on data sheets in Section 3.**

2.3 Battery Index

Table 2

Model Number	Nominal Voltage	Nominal Capacity		Dimensions				Weight (Approx.)	Standard Terminals or Connectors	Page
		10 hour rate	20 hour rate	Length	Width	Height	Total Height (including terminals)			
	(V)	(Ah)	(Ah)	mm (inch)	mm (inch)	mm (inch)	mm (inch)	g (lbs)		
LCS-384E	4	3.8	**4.0**	47.8(1.88)	35.5(1.40)	119(4.69)	119(4.69)	**520**(1.15)	Pressure Contact	23
LCR6V1.2E	6	1.1	**1.2**	97(3.82)	24(0.94)	50(1.97)	56(2.20)	**300**(0.66)	FASTON Type 187	24
LCR-226E	6	2.2	**2.4**	66(2.60)	33(1.30)	104.5(4.11)	104.5(4.11)	**520**(1.15)	"	25
LCR6V3E	6	2.8	**3.0**	134(5.28)	34(1.34)	60(2.36)	66(2.60)	**550**(1.21)	"	26
LCR-306E	6	3.0	**3.2**	66(2.60)	33(1.30)	125(4.92)	125(4.92)	**660**(1.46)	"	27
LCR6V4E	6	3.7	**4.0**	70(2.76)	48(1.89)	102(4.02)	108(4.25)	**830**(1.83)	"	28
LCR6V4EL	6	3.7	**4.0**	70(2.76)	48(1.89)	102(4.02)	102(4.02)	**830**(1.83)	Leadwire Type	29
LCS-386E	6	3.8	**4.0**	51.5(2.03)	47.7(1.88)	119(4.67)	119(4.67)	**690**(1.52)	Pressure Contact	30
LCR-456E	6	4.5	**4.8**	94(3.70)	33(1.30)	125(4.92)	125(4.92)	**920**(2.03)	FASTON Type 187	31
LCR-606E	6	6.0	**6.4**	91(3.58)	49(1.93)	115(4.53)	115(4.53)	**1200**(2.65)	FASTON Type 250	32
LCR6V6.5E	6	6.0	**6.5**	151(5.95)	34(1.34)	94(3.70)	100(3.94)	**1150**(2.54)	FASTON Type 187 or 250	33
LCR6V8EA	6	7.9	**8.0**	151(5.95)	50(1.97)	94(3.70)	100(3.94)	**1750**(3.86)	"	34
LCR-856E	6	8.5	**9.2**	115(4.53)	49(1.93)	115(4.53)	115(4.53)	**1600**(3.53)	FASTON Type 250	35
LCR6V10EA	6	8.8	**10.0**	151(5.95)	50(1.97)	94(3.70)	100(3.94)	**1750**(3.86)	FASTON Type 187 or 250	36
LCR12V1.9E	12	1.8	**1.9**	177(6.97)	34(1.34)	60(2.36)	66(2.60)	**700**(1.54)	FASTON Type 187	37
LCS-2512EL	12	2.5	**2.7**	102(4.02)	55.5(2.19)	80(3.15)	80(3.15)	**1200**(2.65)	Lead wire Type	38
LCR12V3EF	12	2.8	**3.0**	134(5.28)	69(2.72)	60(2.36)	66(2.60)	**1100**(2.43)	FASTON Type 187	39
LCR12V6.5E	12	6.0	**6.5**	151(5.95)	64.5(2.54)	94(3.70)	100(3.94)	**2200**(4.85)	FASTON Type 187 or 250	40
LCR12V24E	12	22.0	**24.0**	175(6.89)	165(6.50)	125(4.92)	125(4.92)	**8.7kg**(19.2)	M5 Bolt and Nut type	41
LCL12V38E	12	34.0	**38.0**	197(7.76)	165(6.50)	175(6.89)	175(6.89)	**14.2kg**(31.3)	M6 Bolt and Nut type	42
LCR12V60E	12	50.0	**60.0**	304(11.97)	171(6.74)	200(7.88)	236(9.30)	**24.0kg**(52.9)	"	43
LCR12V80E	12	70.0	**80.0**	407(16.03)	173(6.82)	210(8.27)	246(9.69)	**36.0kg**(80.0)	M8 Bolt and Nut type	44
LCR12V100E	12	86.0	**100.0**	502(19.77)	180(7.09)	210(8.27)	255(10.04)	**45.0kg**(100.0)	"	45
LCR12V120E	12	104.0	**120.0**	505(19.89)	220(8.67)	210(8.27)	255(10.04)	**52.0kg**(115.0)	"	46
LCR-2212EF	12	2.2	**2.4**	66(2.60)	67(2.64)	104.5(4.11)	104.5(4.11)	**1040**(2.29)	FASTON Type 187	53,54
LCR-2212ES	12	2.2	**2.4**	133(5.24)	34(1.34)	105.5(4.15)	105.5(4.15)	**1050**(2.31)	"	56,57
LCR-3012EF	12	3.0	**3.2**	66(2.60)	67(2.64)	125(4.92)	125(4.92)	**1320**(2.91)	"	53,54
LCR-3012ES	12	3.0	**3.2**	133(5.24)	34(1.34)	126(4.96)	126(4.96)	**1330**(2.93)	"	56,57
LCR-4512EF	12	4.5	**4.8**	94(3.70)	67(2.64)	125(4.92)	125(4.92)	**1850**(4.08)	"	53,54
LCR-4512ES	12	4.5	**4.8**	189(7.44)	34(1.34)	126(4.96)	126(4.96)	**1850**(4.08)	"	56,57
LCR-6012EF	12	6.0	**6.4**	91(3.58)	99(3.90)	115(4.53)	115(4.53)	**2400**(5.29)	FASTON Type 250	53,55
LCR-6012ES	12	6.0	**6.4**	183(7.20)	50(1.97)	116(4.57)	116(4.57)	**2400**(5.29)	"	56,58
LCR-8512EF	12	8.5	**9.2**	115(4.53)	99(3.90)	115(4.53)	115(4.53)	**3200**(7.05)	"	53,55
LCR-8512ES	12	8.5	**9.2**	231(9.09)	50(1.97)	116(4.57)	116(4.57)	**3200**(7.05)	"	56,58
LCR-1812E	12	1.8	**1.9**	200.5(7.89)	24.8(0.98)	60.5(2.38)	60.5(2.38)	**700**(1.54)	DC plug	47
LCS-2012AE	12	2.0	**2.05**	182(7.17)	23.85(0.94)	61.7(2.43)	61.7(2.43)	**635**(1.40)	Pressure Contact	48
LCS-2012E	12	2.0	**2.1**	200.7(7.90)	24.8(0.98)	61.7(2.43)	61.7(2.43)	**700**(1.54)	"	49
LCR-3012VBE	12	3.0	**3.2**	240(9.45)	34(1.34)	69(2.72)	69(2.72)	**1320**(2.91)	DC Plug	50

2.4 Ampere-Hour Selection Chart



Note: See Battery Selection, Page 19
Battery Index, Page 20
and Battery Chart Page 22

Table 3 Selected Ah vs Battery types

Amp HRS 20 hour rate	Battery Types		
	4 volt	6 volt	12 volt
1.2		LCR6V1.2E	
1.9			LCR12V1.9E, LCR-1812E
2.05			LCS-2012AE
2.1			LCS-2012E
2.4		LCR-226E	LCR-2212EF, 2212ES
2.7			LCS-2512EL
3.0		LCR-6V3E	LCR12V3EF
3.2		LCR-306E	LCR-3012EF, 3012ES, 3012VBE
4.0	LCS-384E	LCS-386E, LCR6V4E, 6V4EL	
4.8		LCR-456E	LCR-4512EF, 4512ES
6.4		LCR-606E	LCR-6012EF, 6012ES
6.5		LCR6V6. 5E	LCR12V6.5E
8.0		LCR6V8EA	
9.2		LCR-856E	LCR-8512EF, 8512ES
10.0		LCR6V10EA	
24.0			LCR12V24E
38.0			LCL12V38E
60.0			LCR12V60E
80.0			LCR12V80E
100.0			LCR12V100E
120.0			LCR12V120E

Note: See Battery Selection -Page 19,
Battery Index -Page 20,
Ah Selector Chart -Page 21.

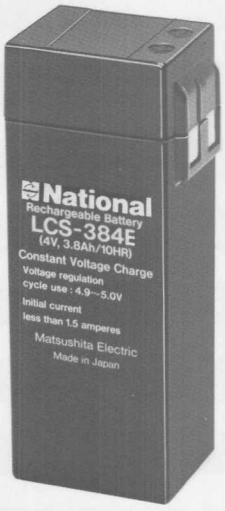
3. Individual Specifications

LCS-384E (NEW)

■ Specification

Nominal Voltage		4V
Nominal Capacity (20 hour rate)		4.0Ah
Dimensions	Total Height Height Length Width	119 mm (4.69 inches) 119 mm (4.69 inches) 47.8mm (1.88 inches) 35.5mm (1.40 inches)
Weight		Approx. 520 g (1.15 lbs)

Note: Excellent for cordless appliances, vacuums, lights. Can accept rapid charge.

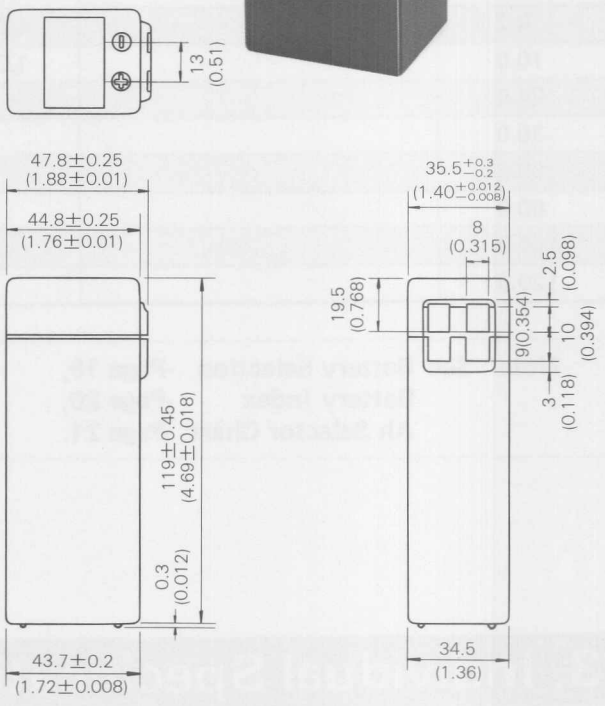


■ Characteristics

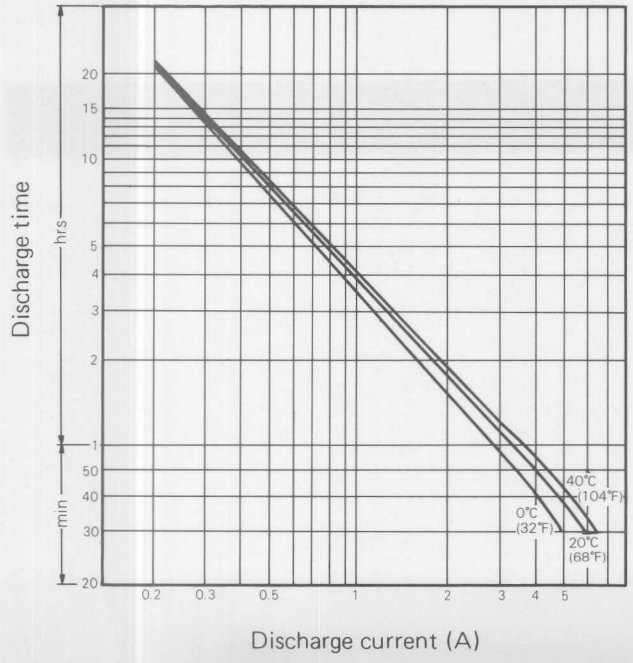
Capacity	20 hour rate (200mA) 10 hour rate (380mA) 5 hour rate (740mA) 1 hour rate (3,400mA)	4.0Ah 3.8Ah 3.7Ah 3.4Ah
	1.5 hour discharge to 3.5V	2.1A
Internal Resistance	Full charged Battery (20° C, 68° F)	13mΩ
Capacity affected by temperature	40° C (104° F) 20° C (68° F) 0° C (32° F) –20° C (–4° F)	102% 100% 85% 60%
Self-Discharge (20°C,68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	90% 80% 60%
Terminal	Pressure Contact	
Charge (Constant voltage) Cycle	Initial Charging Current less than 1.5A Voltage4.9–5.0V/4V20°C (68°F)	

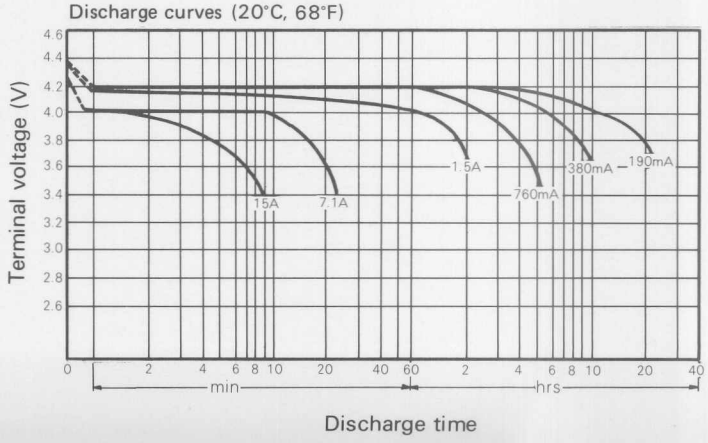
Note : Not designed for float service.

Unit: mm(inch)



■ Discharging Current & Discharge Duration Time

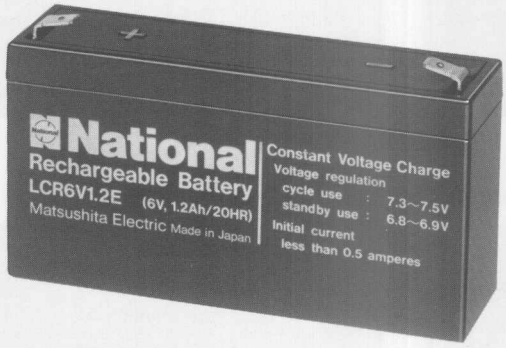




LCR 6V1.2E (formerly 6M1.2E)

■ Specification

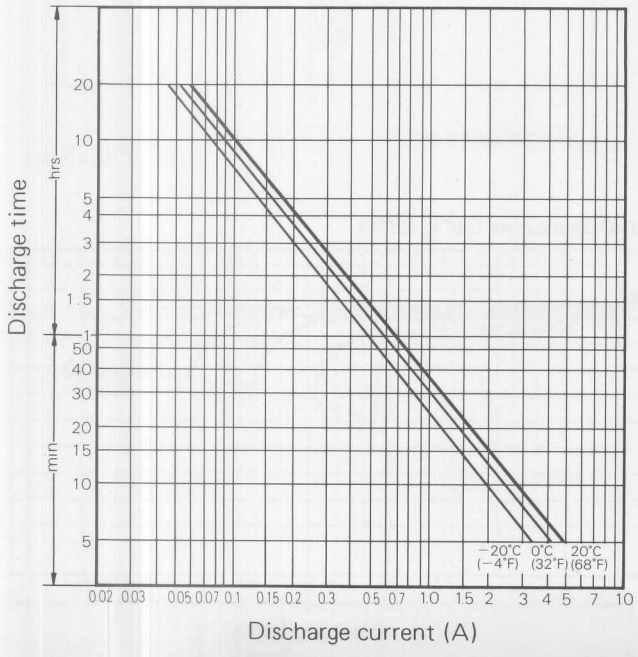
Nominal Voltage		6V
Nominal Capacity (20 hour rate)		1.2Ah
Dimensions	Total Height (with terminals)	56 mm (2.20 inches)
	Height	50 mm (1.97 inches)
	Length	97 mm (3.82 inches)
	Width	24 mm (0.94 inches)
Weight		Approx. 300 g (0.67 lbs)



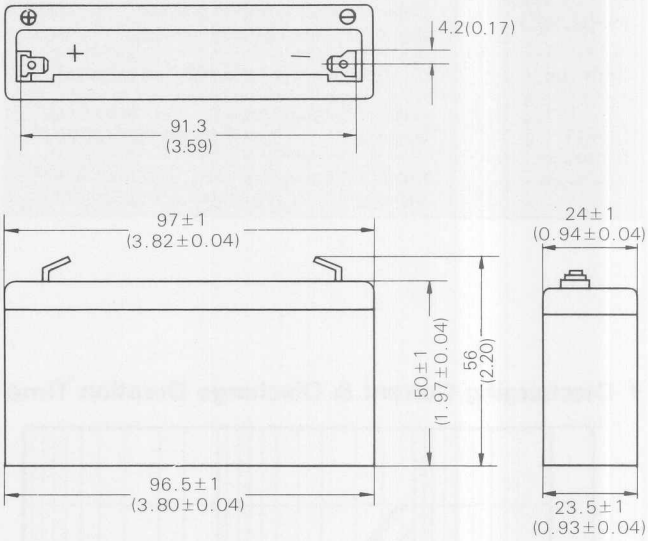
■ Characteristics

Capacity		20 hour rate (60mA) 10 hour rate (110mA) 5 hour rate (180mA) 1 hour rate (650mA)	1.2Ah 1.1Ah 0.9Ah 0.65Ah
		1.5 hour discharge to 5.25V	0.48A
Internal Resistance		Full charged Battery (20°C, 68°F)	60mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		AMP Faston type 187 Tab terminal	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 0.5A Voltage 7.3–7.5V/6V 20°C (68°F)	
	Float	Initial Charging Current less than 0.5A Voltage 6.8–6.9V/6V 20°C (68°F)	

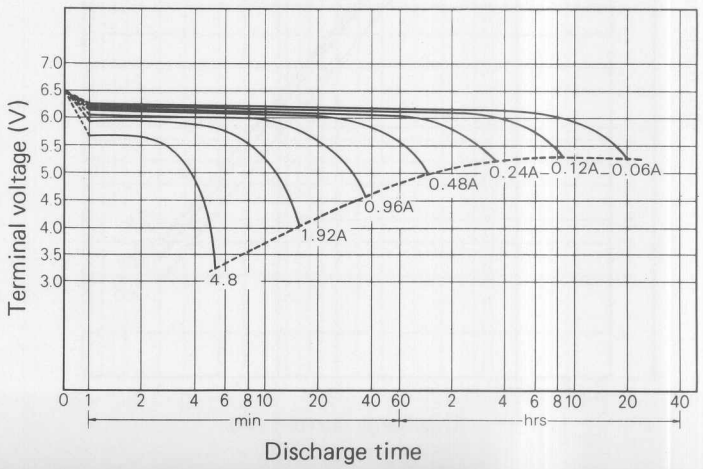
■ Discharging Current & Discharge Duration Time



Unit: mm(inch)



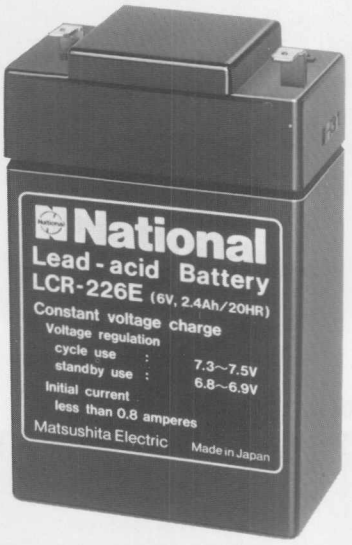
Discharge curves (20°C, 68°F)



LCR-226E

■ Specification

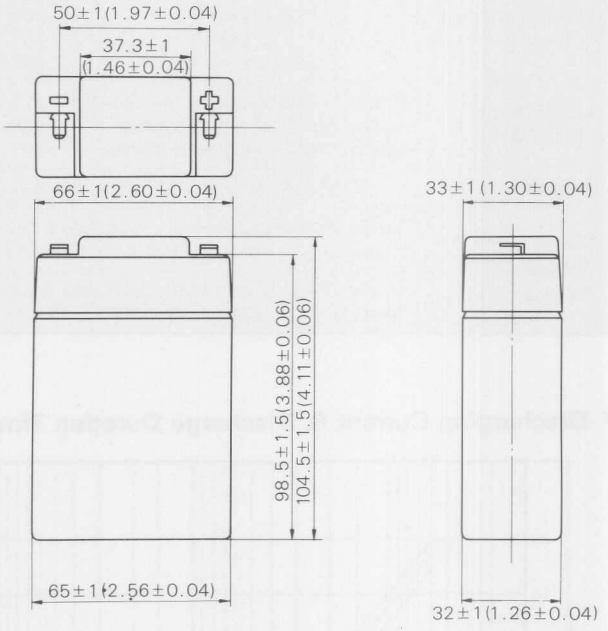
Nominal Voltage		6V
Nominal Capacity		2.4 Ah (20 hour rate)
Dimensions	Total Height	104.5mm (4.11 inches)
	Length	66mm (2.60 inches)
	Width	33mm (1.30 inches)
Weight		Approx. 520g (1.15 lbs)



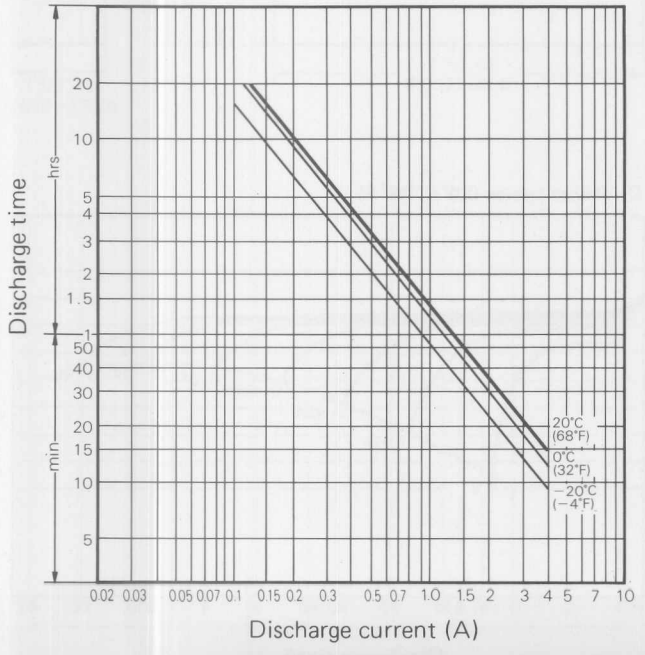
■ Characteristics

Capacity		20 hour rate (118mA) 10 hour rate (220mA) 5 hour rate (400mA) 1 hour rate (1,460mA)	2.4Ah 2.2Ah 2.0Ah 1.5Ah
		1.5 hour discharge to 5.25V	1.0A
Internal Resistance		Full charged Battery (20°C, 68°F)	45mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		AMP Faston type 187 Tab terminal	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 0.96A Voltage 7.3–7.5V/6V 20°C (68°F)	
	Float	Initial Charging Current less than 0.96A Voltage 6.8–6.9V/6V 20°C (68°F)	

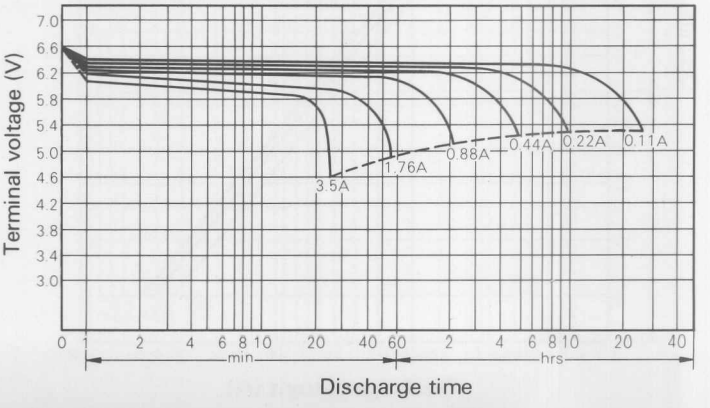
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



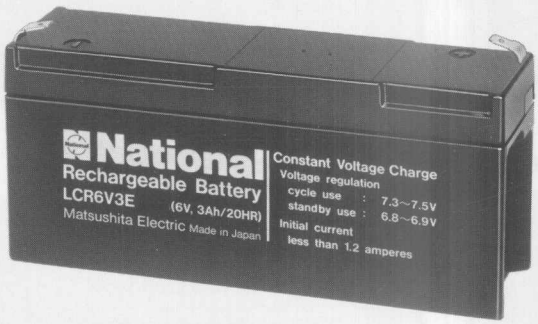
Discharge curves (20° C, 68° F)



LCR 6V3E

■ Specification

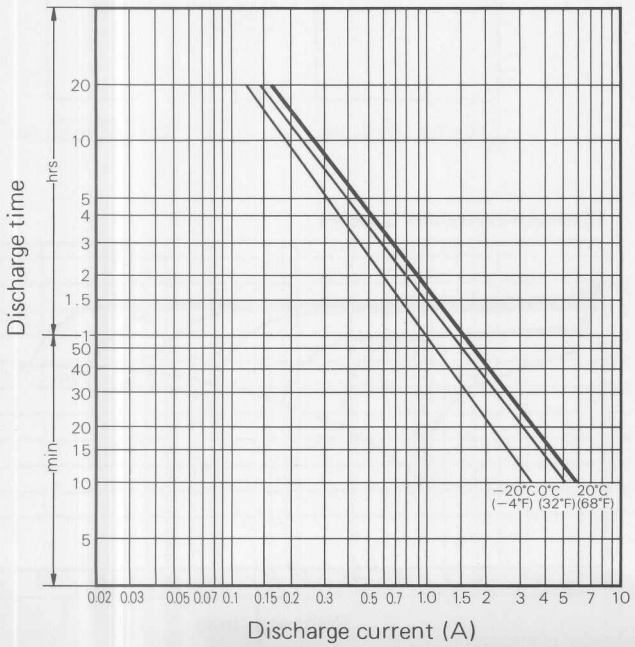
Naminal Voltage		6V
Nominal Capacity		3 Ah (20 hour rate)
Dimensions	Total Height (with terminals)	66 mm (2.60 inches)
	Height	60 mm (2.36 inches)
	Length	134 mm (5.84 inches)
	Width	34 mm (1.34 inches)
Weight		Approx. 550g (1.21 lbs)



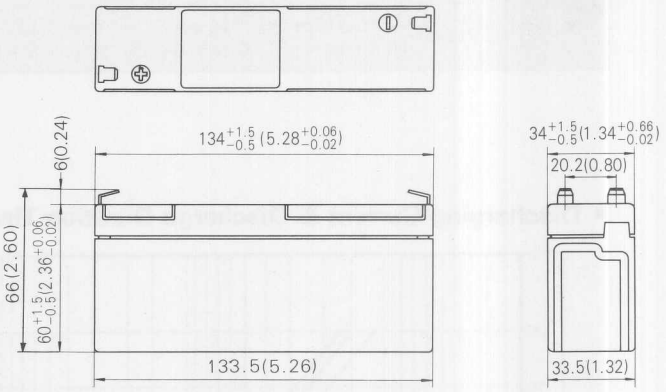
■ Characteristics

Capacity		20 hour rate (150mA) 10 hour rate (280mA) 5 hour rate (480mA) 1 hour rate (1800mA)	3.0Ah 2.8Ah 2.4Ah 1.8Ah
		1.5 hour discharge to 5.25V	1.3A
Internal Resistance		Full charged Battery (20°C,68°F)	30mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) –20°C (–4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Max. Discharge Current (20°C, 68°F)		60A	
Terminal		AMP Faston type 187 Tab Terminal	
Charge (Constant Voltage)	Cycle	Initial Charging Current less than 1.2 A Voltage 7.3–7.5V/6V 20°C (68°F)	
	Float	Initial Charging Current less than 1.2 A Voltage 6.8–6.9V/6V 20°C (68°F)	

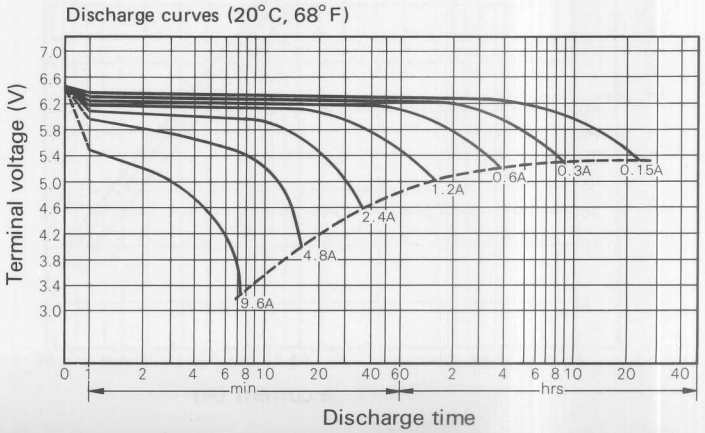
■ Discharging Current & Discharge Duration Time



Unit: mm(inch)



Discharge curves (20°C, 68°F)



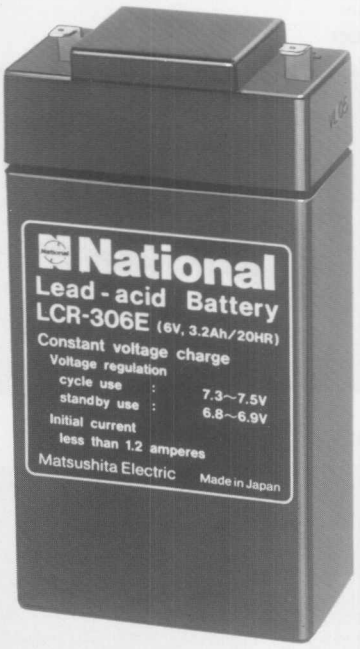
LCR-306E

■ Specification

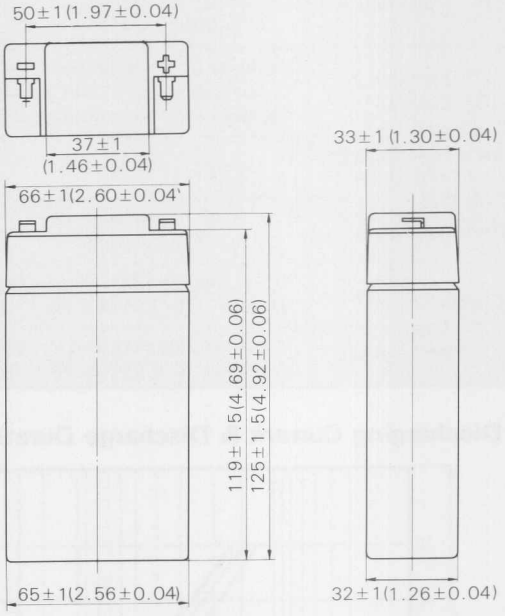
Nominal Voltage		6V
Nominal Capacity (20 hour rate)		3.2Ah
Dimensions	Total Height	125mm (4.92 inches)
	Length	66mm (2.60 inches)
	Width	33mm (1.30 inches)
Weight		Approx. 660g (1.46 lbs)

■ Characteristics

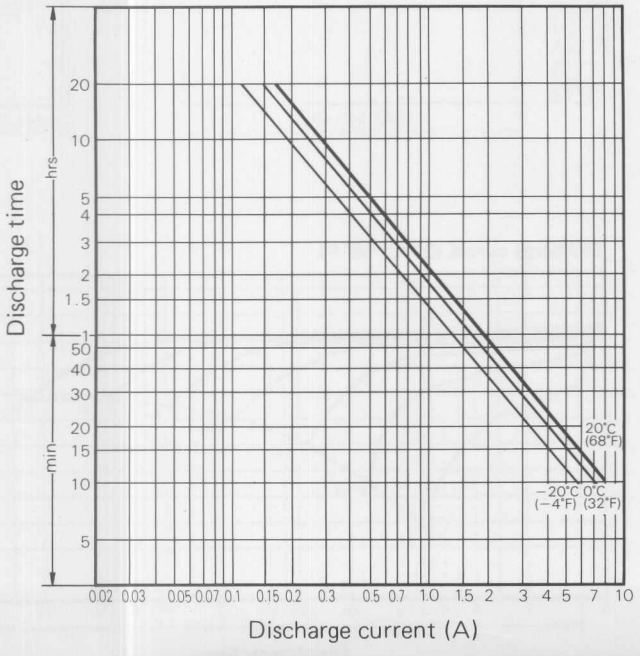
Capacity	20 hour rate (160mA) 10 hour rate (300mA) 5 hour rate (560mA) 1 hour rate (2000mA)	3.2Ah 3.0Ah 2.8Ah 2.0Ah
	1.5 hour discharge to 5.25V	1.3A
Internal Resistance	Full charged Battery (20°C, 68°F)	40mΩ
Capacity affected by Temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal	AMP Faston type 187 Tab terminal	
Charge (Constant voltage) — Cycle	Initial Charging Current less than 1.28A Voltage 7.3–7.5V/6V 20°C (68°F)	
Charge (Constant voltage) — Float	Initial Charging Current less than 1.28A Voltage 6.8–6.9V/6V 20°C (68°F)	



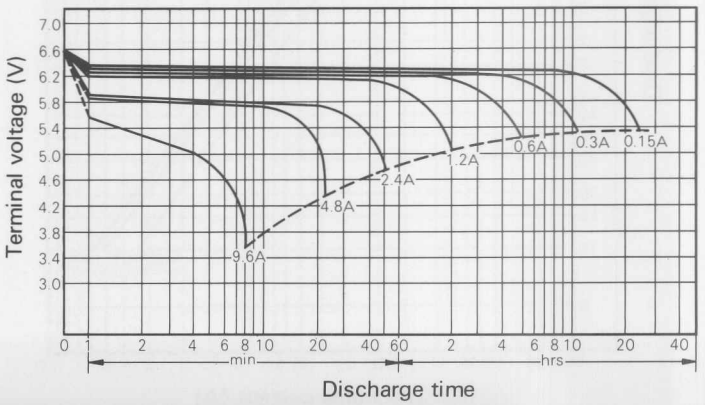
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)

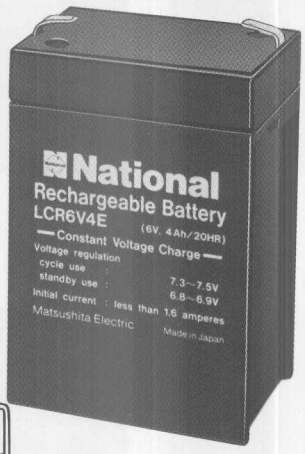


LCR 6V4E

■ Specification

Nominal Voltage		6V
Nominal Capacity (20 hour rate)		4Ah
Dimensions	Total Height Height Length Width	108 mm (4.25 inches) 102 mm (4.05 inches) 70 mm (2.76 inches) 48 mm (1.89 inches)
Weight		Approx. 830g (1.83 lbs)

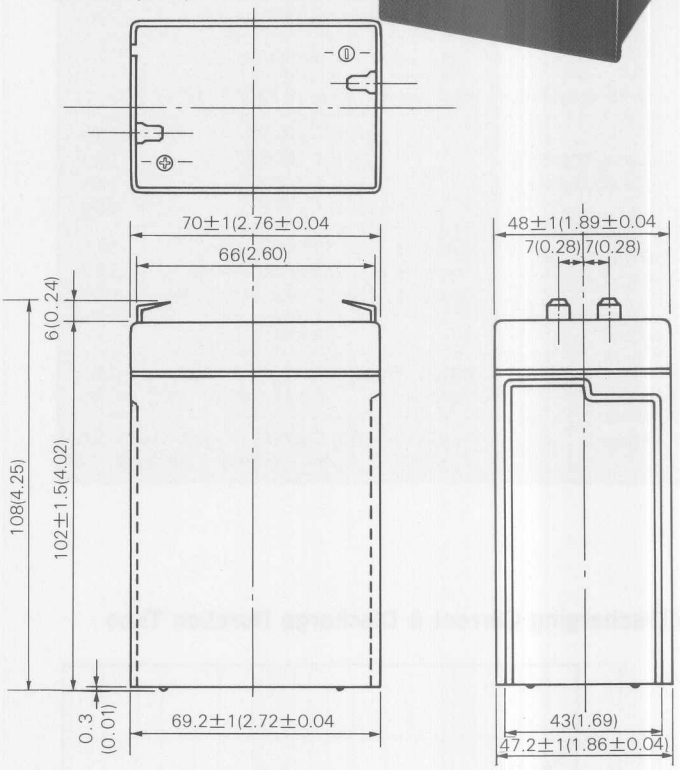
Note: Excellent for alarm systems and exit lights.



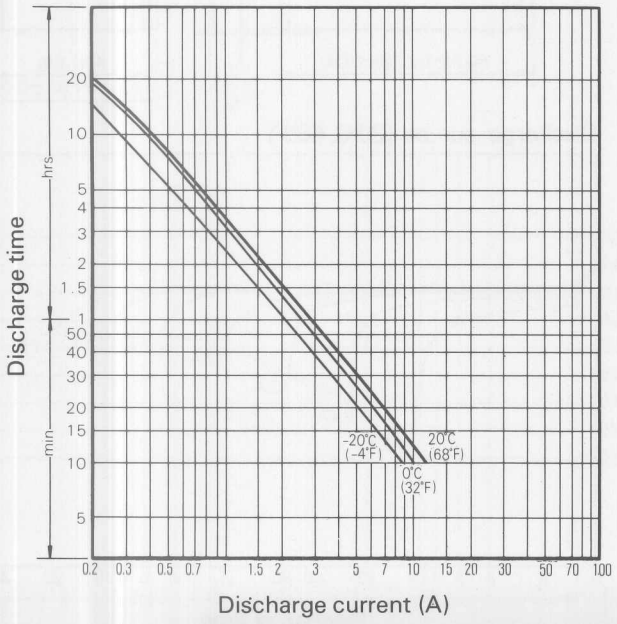
■ Characteristics

Capacity	20 hour rate (200mA) 10 hour rate (370mA) 5 hour rate (660mA) 1 hour rate (2,700mA)	4.0Ah 3.7Ah 3.3Ah 2.7Ah
	1.5 hour discharge to 5.25V	1.9A
Internal Resistance	Full charged Battery (20°C, 68°F)	25mΩ
Capacity affected by temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal	AMP Faston type 187	
Charge (Constant voltage) — Cycle	Initial Charging Current less than 1.6A Voltage 7.3—7.5V/6V 20°C (68°F)	
Charge (Constant voltage) — Float	Initial Charging Current less than 1.6A Voltage 6.8—6.9V/6V 20°C (68°F)	

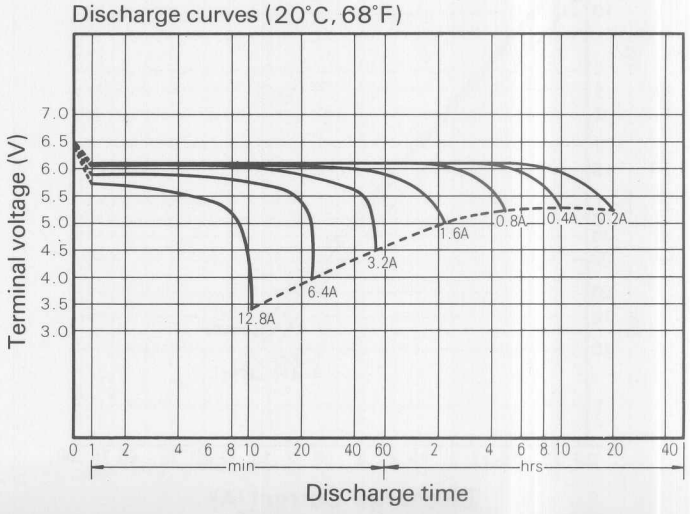
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



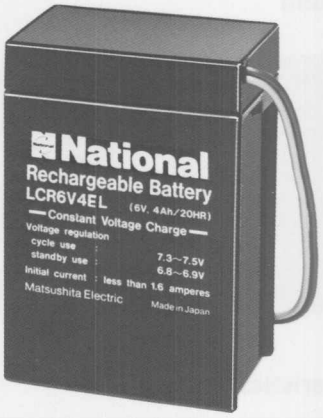
Discharge curves (20°C, 68°F)



LCR 6V4EL

■ Specification

Nominal Voltage		6V
Nominal Capacity (20 hour rate)		4Ah
Dimensions	Total Height Height Length Width	102mm (4.02inches) 102mm (4.02inches) 70mm (2.76inches) 48mm (1.86inches)
Weight		Approx. 830g (1.83 lbs)

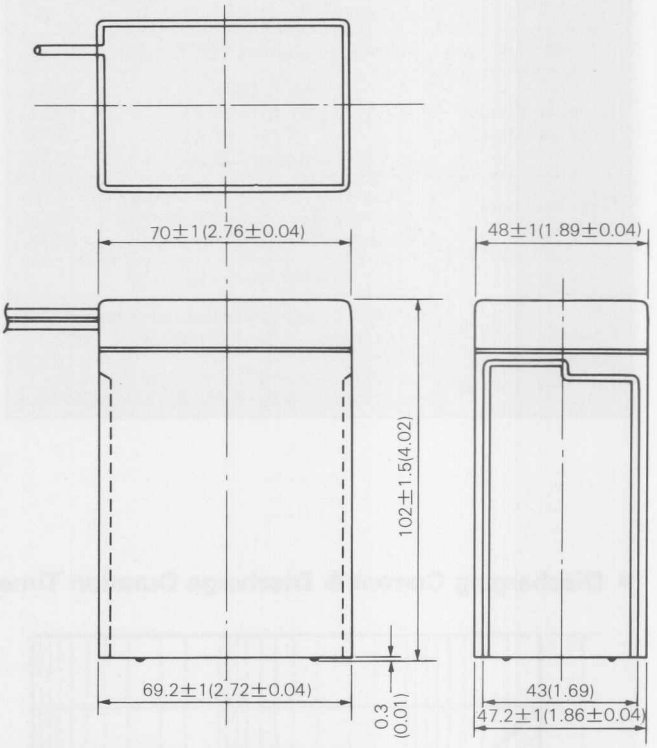


■ Characteristics

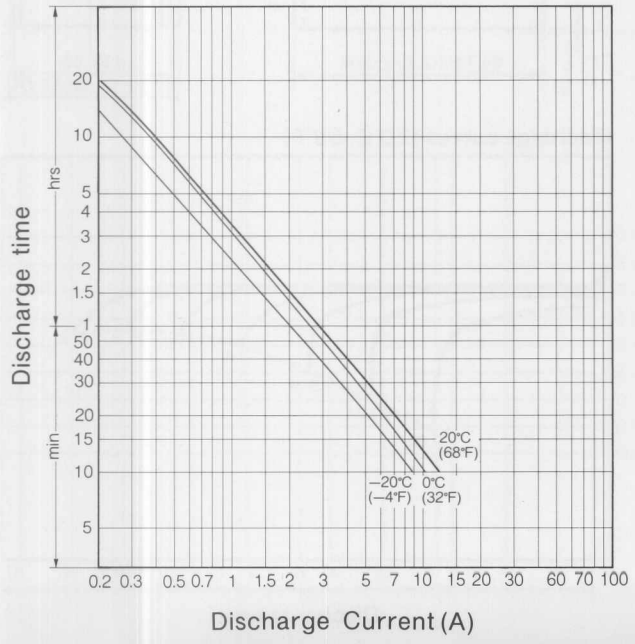
Capacity		20 hour rate (200mA) 10 hour rate (370mA) 5 hour rate (660mA) 1 hour rate (2700mA)	4.0Ah 3.7Ah 3.3Ah 2.7Ah
		1.5 hour discharge to 5.25V	1.9A
Internal Resistance		Full charged Battery (20°C, 68°F)	25mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		Leadwire type	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 1.6A Voltage 7.3–7.5V/6V 20°C (68°F)	
	Float	Initial Charging Current less than 1.6A Voltage 6.8–6.9V/6V 20°C (68°F)	

Wire:
AWM UL Style 1007 AWG18

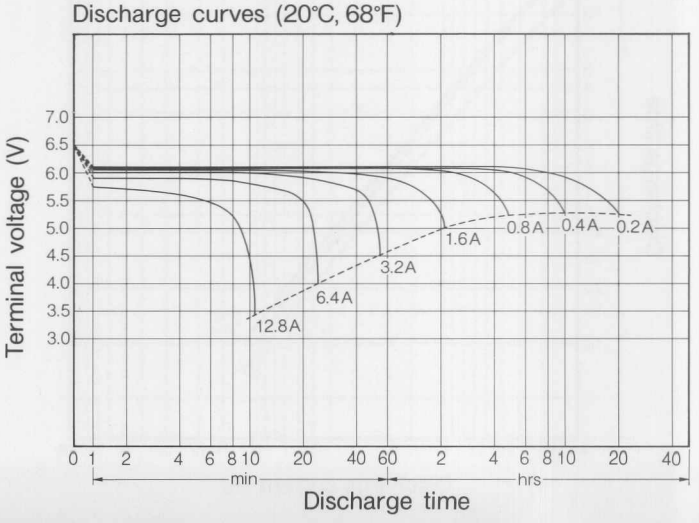
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCS-386E (NEW)

■ Specification

Nominal Voltage		6V
Nominal Capacity (20 hour rate)		4.0Ah
Dimensions	Total Height	119 mm (4.67 inches)
	Height	119 mm (4.67 inches)
	Length	51.5 mm (2.03 inches)
	Width	47.7 mm (1.88 inches)
Weight		Approx. 690 g (1.52 lbs)

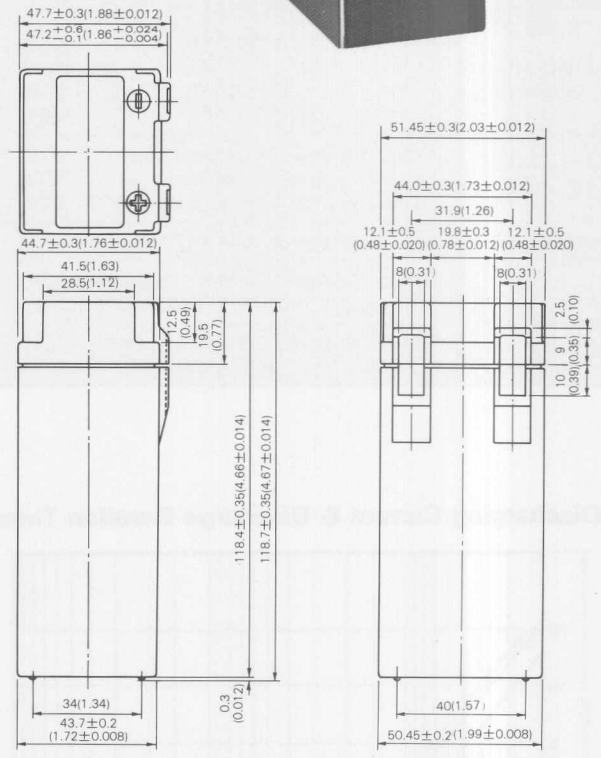
Note: Excellent for applications and high drain. Can accept rapid charge.

■ Characteristics

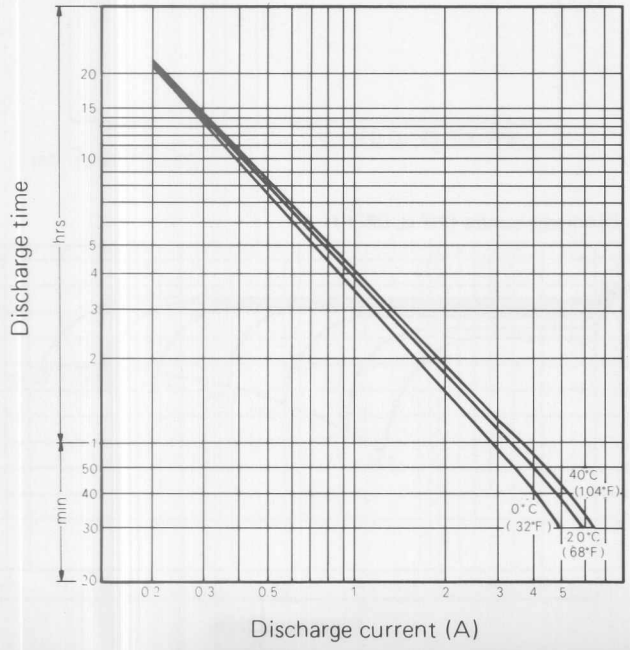
Capacity	20 hour rate (200mA)	4.0Ah
	10 hour rate (380mA)	3.8Ah
	5 hour rate (740mA)	3.7Ah
	1 hour rate (3,400mA)	3.4Ah
	1.5 hour discharge to 5.25V	2.1A
Internal Resistance	Full charged Battery (20°C, 68°F)	20mΩ
Capacity affected by temperature	40°C (104°F)	102%
	20°C (68°F)	100%
	0°C (32°F)	85%
	–20°C (–4°F)	60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage	90%
	Capacity after 6 month storage	80%
	Capacity after 12 month storage	60%
Terminal	Pressure Contact	
Charge (Constant voltage) Cycle	Initial Charging Current less than 1.5A Voltage7.3—7.5V/6V 20°C (68°F)	

Note : Not designed for float service.

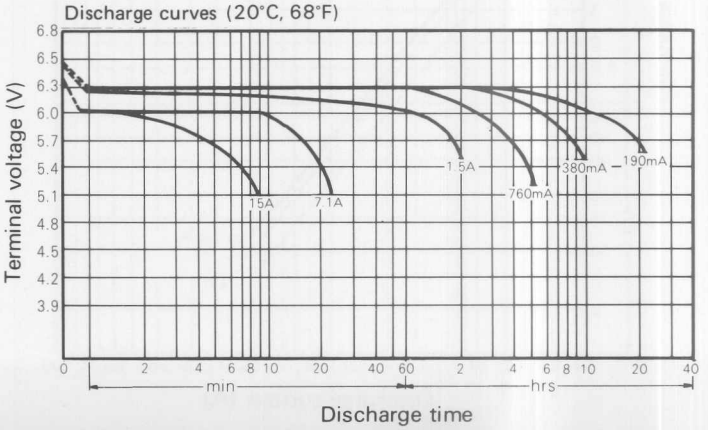
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



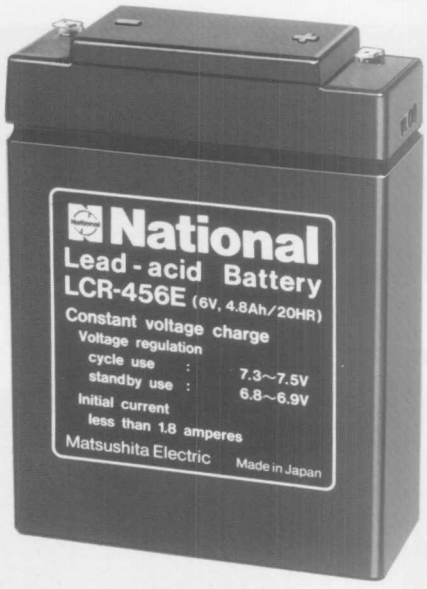
Discharge curves (20°C, 68°F)



LCR-456E

■ Specification

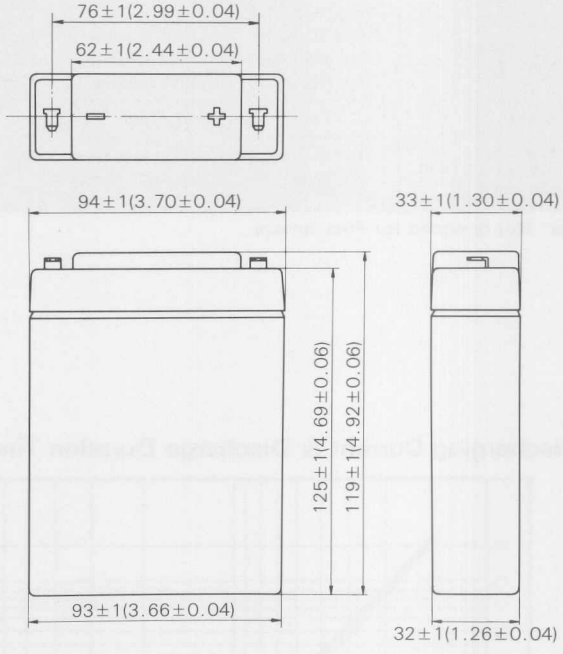
Nominal Voltage		6V
Nominal Capacity (20 hour rate)		4.8Ah
Dimensions	Total Height	125mm (4.92 inches)
	Length	94mm (3.70 inches)
	Width	33mm (1.30 inches)
Weight		Approx. 920g (2.03 lbs)



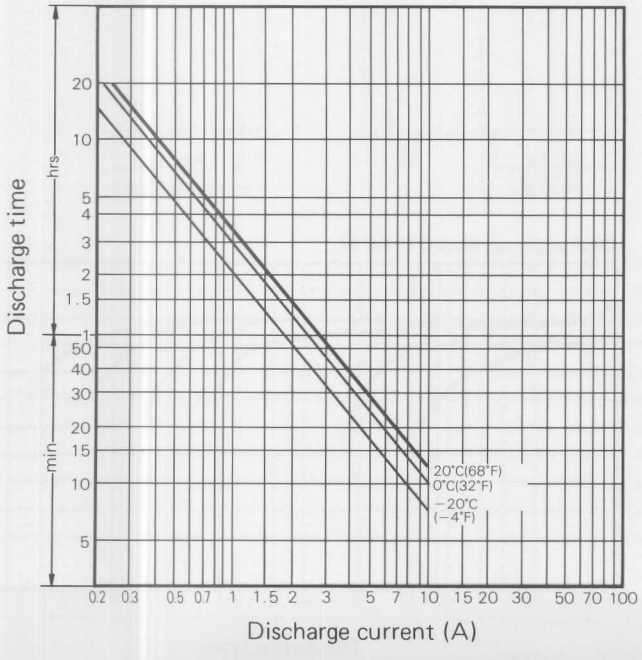
■ Characteristics

Capacity	20 hour rate (240mA) 10 hour rate (450mA) 5 hour rate (820mA) 1 hour rate (3000mA)	4.8Ah 4.5Ah 4.1Ah 3.0Ah
	1.5 hour discharge to 5.25V	2.0A
Internal Resistance	Full charged Battery (20°C, 68°F)	30mΩ
Capacity affected by Temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) –20°C (–4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal	AMP Faston type 187 Tab terminal	
Charge (Constant voltage) — Cycle	Initial Charging Current less than 1.92A Voltage 7.3–7.5V/6V 20°C (68°F)	
Charge (Constant voltage) — Float	Initial Charging Current less than 1.92A Voltage 6.8–6.9V/6V 20°C (68°F)	

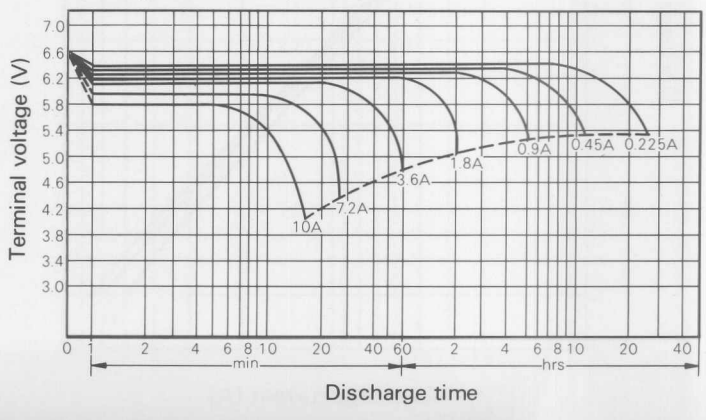
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



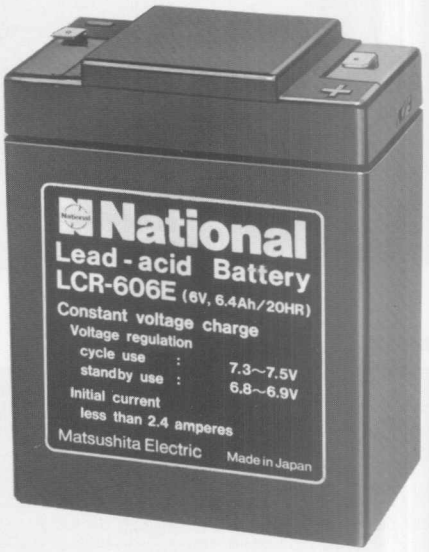
Discharge curves (20°C, 68°F))



LCR-606E

■ Specification

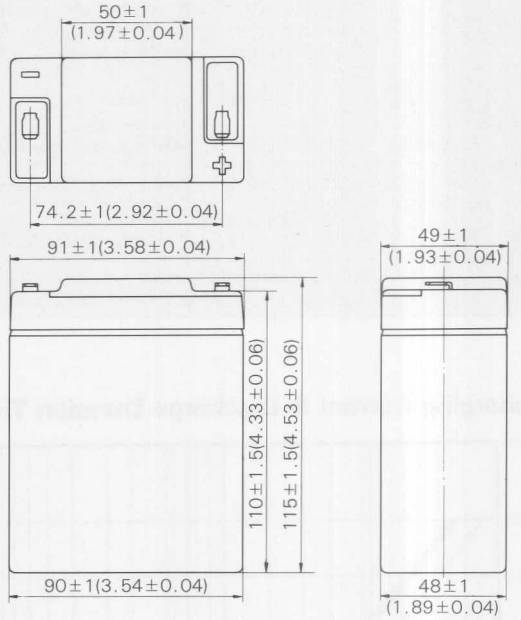
Nominal Voltage		6V
Nominal Capacity (20 hour rate)		6.4Ah
Dimensions	Total Height	115mm (4.53 inches)
	Length	91mm (3.58 inches)
	Width	49mm (1.93 inches)
Weight		Approx. 1200g (2.65 lbs)



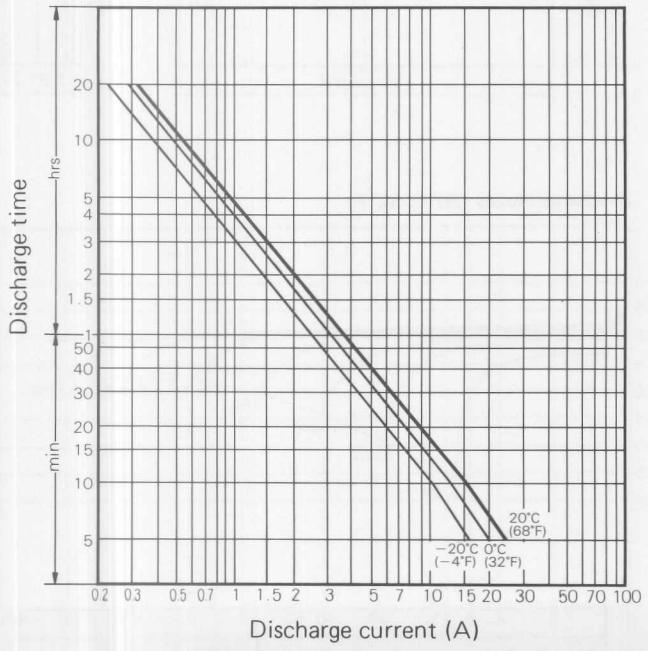
■ Characteristics

Capacity	20 hour rate (320mA) 10 hour rate (600mA) 5 hour rate (1100mA) 1 hour rate (4000mA)	6.4Ah 6.0Ah 5.5Ah 4.0Ah
	1.5 hour discharge to 5.25V	2.6A
Internal Resistance	Full charged Battery (20°C, 68°F)	20mΩ
Capacity affected by Temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal	AMP Faston type 250 Tab terminal	
Charge (Constant voltage) — Cycle	Initial Charging Current less than 2.56A Voltage 7.3–7.5V/6V 20°C (68°F)	
Charge (Constant voltage) — Float	Initial Charging Current less than 2.56A Voltage 6.8–6.9V/6V 20°C (68°F)	

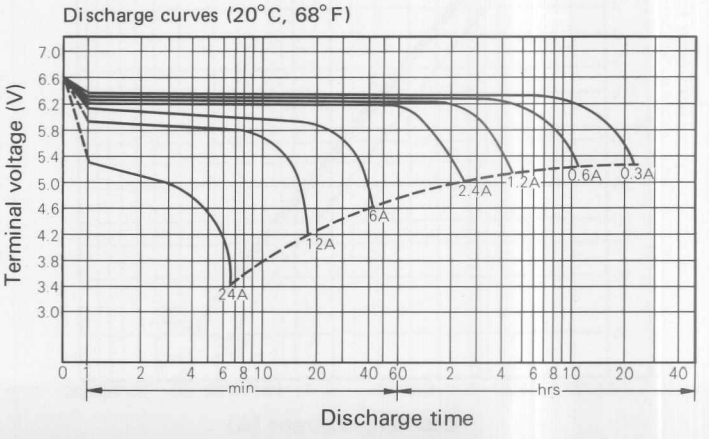
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR 6V6.5E

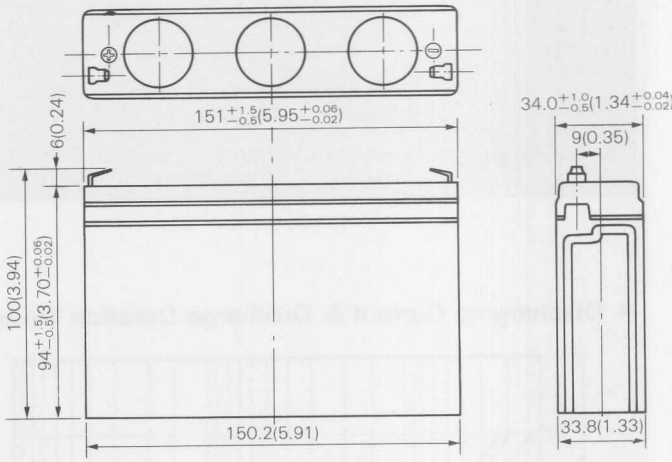
■ Specification

Nominal Voltage		6V
Nominal Capacity		6.5Ah
Dimensions	Total Height	100 mm (3.94 inches)
	Height	94 mm (3.70 inches)
	Length	151 mm (5.95 inches)
	Width	34 mm (1.34 inches)
Weight		Approx. 1150 g (2.54 lbs)

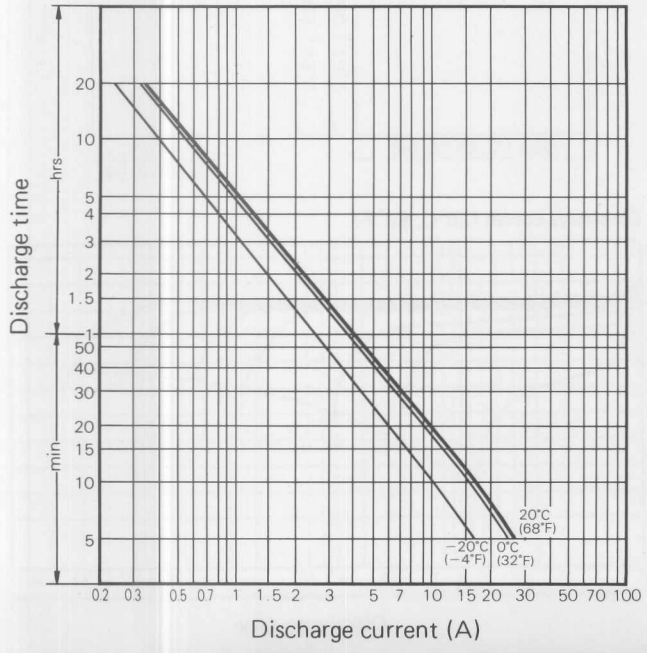
■ Characteristics

Capacity		20 hour rate (325mA) 10 hour rate (600mA) 5 hour rate (1040mA) 1 hour rate (4000mA)	6.5Ah 6.0Ah 5.2Ah 4.0Ah
		1.5 hour discharge to 5.25V	2.9A
Internal Resistance		Full charged Battery (20°C, 68°F)	20mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Maximum Discharge Current (20°C, 68°F)		80A (Continuous)	
Terminal	Standard	LCR 6V6.5E AMP Faston type 187	
	Optional	LCR 6V6.5E-1 AMP Faston type 250	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 2.6A Voltage 7.3–7.5V/6V 20°C (68°F)	
	Float	Initial Charging Current less than 2.6A Voltage 6.8–6.9V/6V 20°C (68°F)	

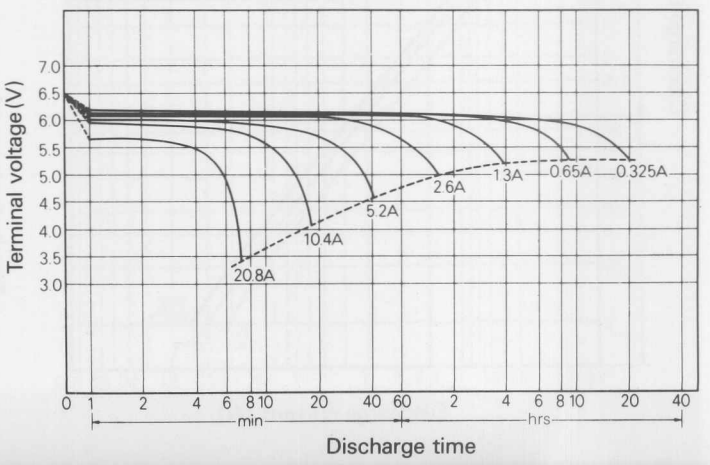
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR 6V8EA (formerly LCR-806E)

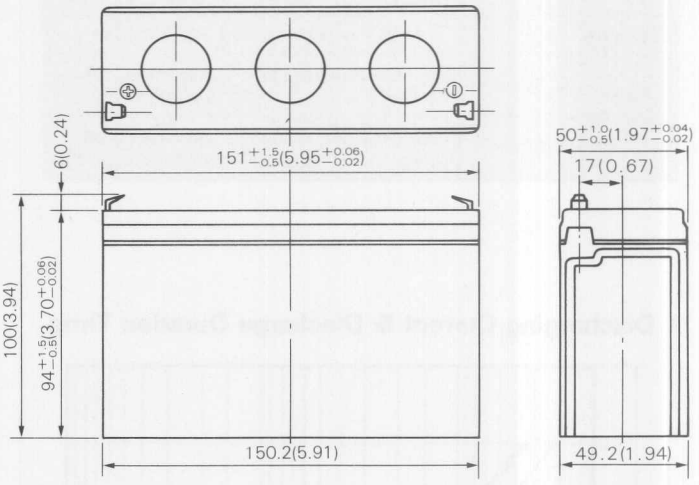
■ Specification

Nominal Voltage		6V
Nominal Capacity (20 hour race)		8 Ah
Dimensions	Total Height (with terminals)	100 mm (3.94 inches)
	Height	94 mm (3.70 inches)
	Length	151 mm (5.95 inches)
	Width	50 mm (1.97 inches)
Weight		Approx. 1750 g (3.86 lbs)

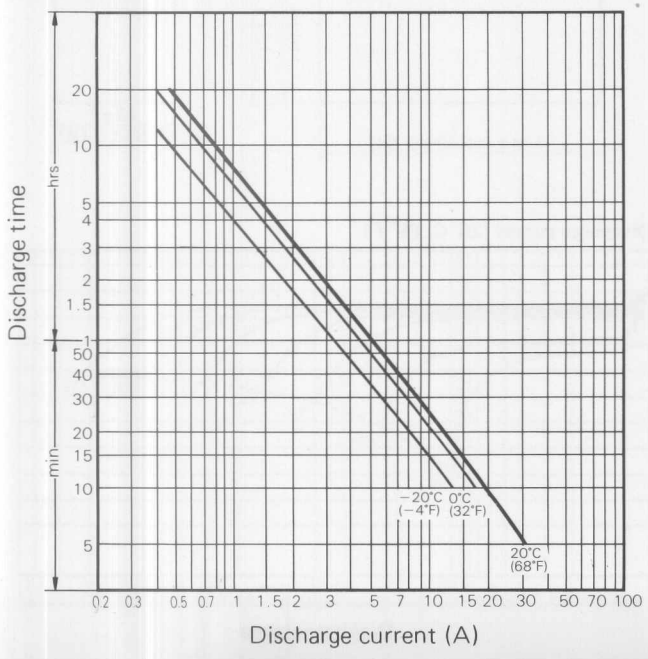
■ Characteristics

Capacity		20 hour rate (400mA) 10 hour rate (740mA) 5 hour rate (1360mA) 1 hour rate (4800mA)	8.0Ah 7.4Ah 6.8Ah 4.8Ah
		1.5 hour discharge to 5.25V	3.5A
Internal Resistance		Full charged Battery (20°C, 68°F)	25mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) –20°C (–4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Maximum Discharge Current (20°C, 68°F)		80A (Continuous)	
Terminal	Standard	LCR 6V8EA AMP Faston type 187	
	Optional	LCR 6V8EA-1 AMP Faston type 250	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 3.2A Voltage 7.3–7.5V/6V 20°C (68°F)	
	Float	Initial Charging Current less than 3.2A Voltage 6.8–6.9V/6V 20°C (68°F)	

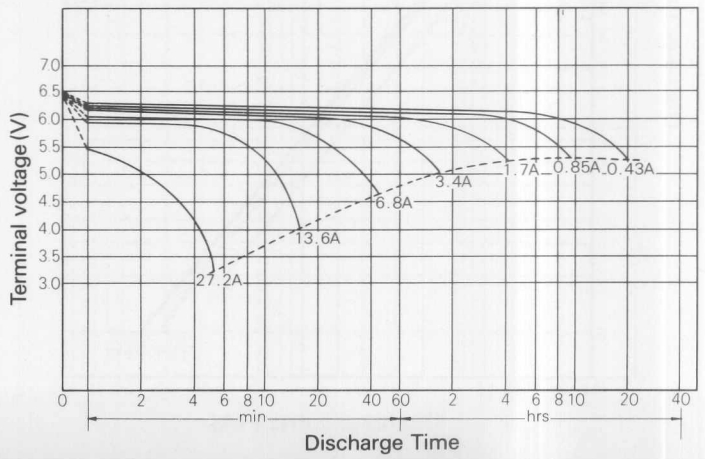
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



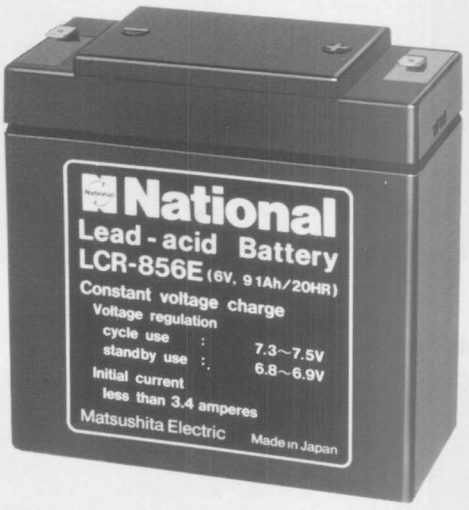
Discharge curves (20°C, 68°F)



LCR-856E

■ Specification

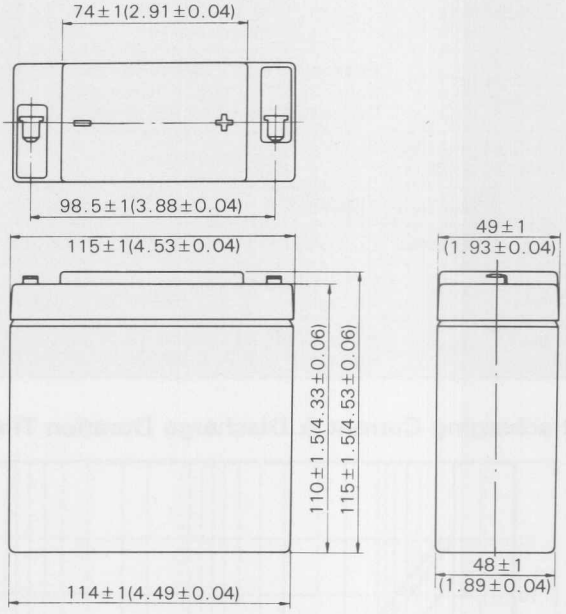
Nominal Voltage		6V
Nominal Capacity (20 hour rate)		9.2Ah
Dimensions	Total Height	115mm (4.53 inches)
	Length	115mm (4.53 inches)
	Width	49mm (1.93 inches)
Weight		Approx. 1600g (3.54 lbs)



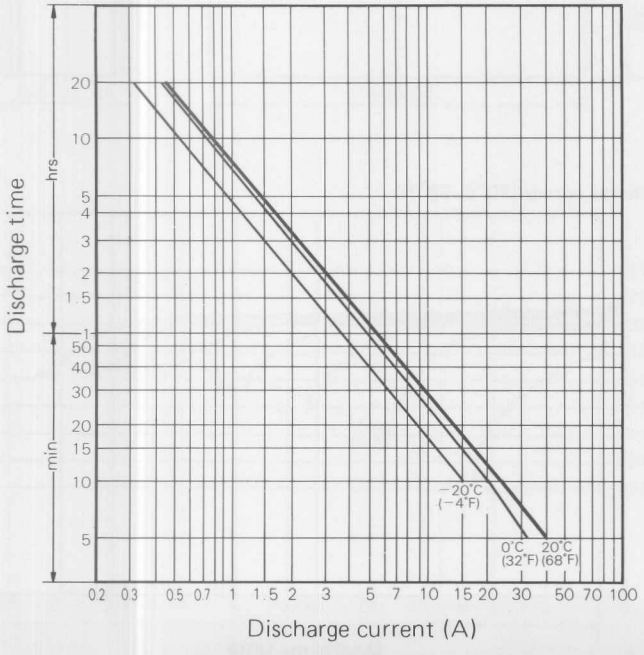
■ Characteristics

Capacity	20 hour rate (460mA)	9.2Ah
	10 hour rate (850mA)	8.5Ah
	5 hour rate (1500mA)	7.5Ah
	1 hour rate (5600mA)	5.6Ah
	1.5 hour discharge to 5.25V	3.9A
Internal Resistance	Full charged Battery (20°C, 68°F)	20mΩ
Capacity affected by Temperature	40°C (104°F)	105%
	20°C (68°F)	100%
	0°C (32°F)	85%
	−20°C (−4°F)	60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage	91%
	Capacity after 6 month storage	82%
	Capacity after 12 month storage	64%
Terminal	AMP Faston type 250 Tab terminal	
Charge (Constant voltage) Cycle	Initial Charging Current less than 3.68A Voltage 7.3–7.5V/6V 20°C (68°F)	
Charge (Constant voltage) Float	Initial Charging Current less than 3.68A Voltage 6.8–6.9V/6V 20°C (68°F)	

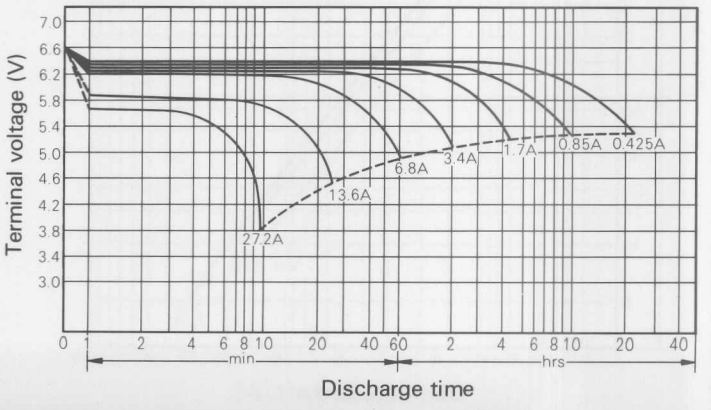
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR 6V10EA (formerly LCR-1006E)

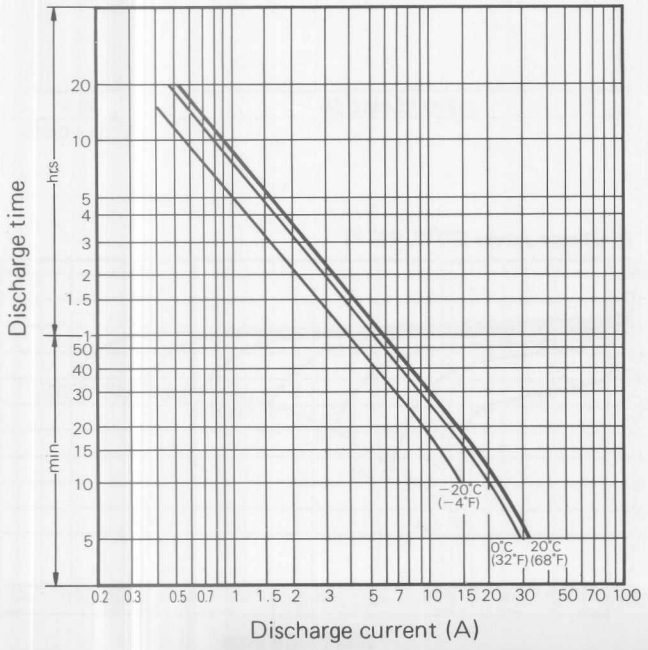
■ Specification

Nominal Voltage		6V
Nominal Capacity (20 hour rate)		10Ah
Dimensions	Total Height (with terminals)	100 mm (3.94 inches)
	Height	94 mm (3.70 inches)
	Length	151 mm (5.95 inches)
	Width	50 mm (1.97 inches)
Weight		Approx. 1750g (3.86 lbs)

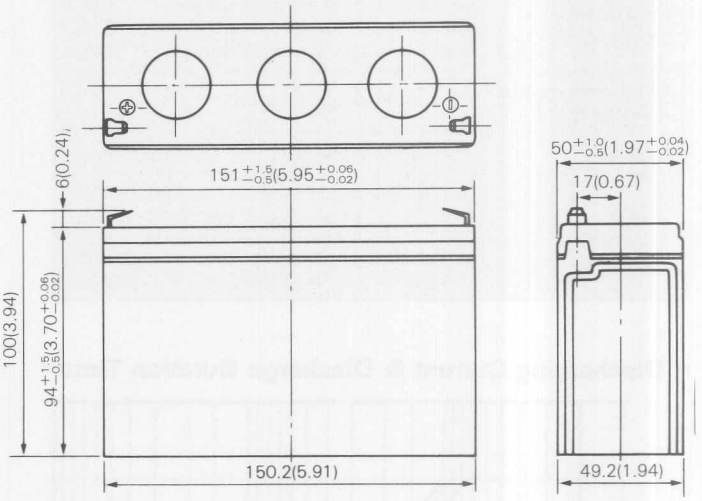
■ Characteristics

Capacity		20 hour rate (500mA) 10 hour rate (930mA) 5 hour rate (1700mA) 1 hour rate (6000mA)	10.0Ah 9.3Ah 8.5Ah 6.0Ah
		1.5 hour discharge to 5.25V	4.8A
Internal Resistance		Full charged Battery (20°C, 68°F)	1.5mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Maximum Discharge Current (20°C, 68°F)		80A (continuous)	
Terminal	Standard	LCR 6V10EA	AMP Faston type 187
	Optional	LCR 6V10EA-1	AMP Faston type 250
Charge (Constant voltage)	Cycle	Initial Charging Current less than 4.0A Voltage 7.3–7.5V/6V 20°C (68°F)	
	Float	Initial Charging Current less than 4.0A Voltage 6.8–6.9V/6V 20°C (68°F)	

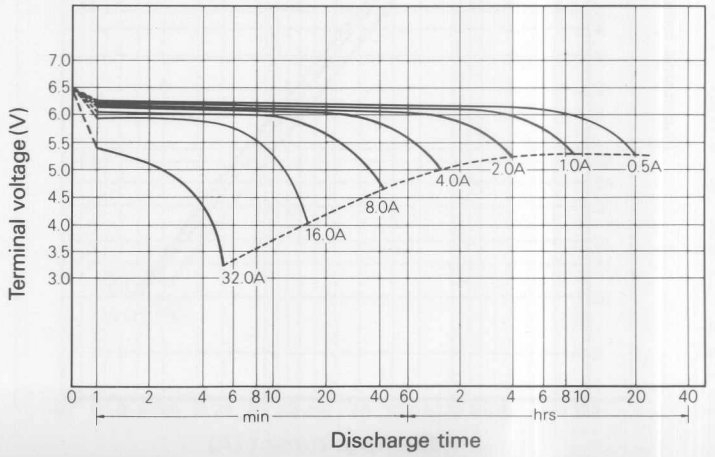
■ Discharging Current & Discharge Duration Time



Unit: mm(inch)



Discharge curves (20°C, 68°F)



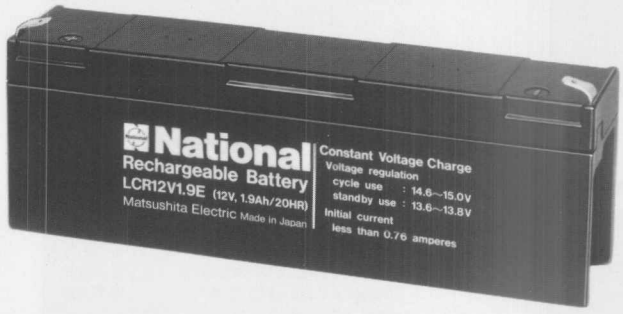
LCR 12V1.9E

■ Specification

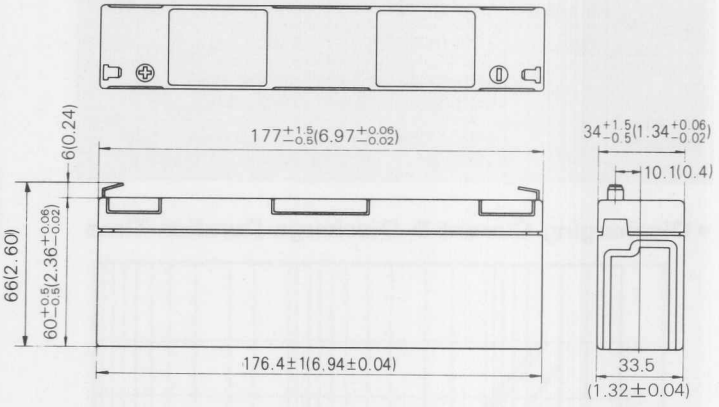
Naminal Voltage		12V
Nominal Capacity		1.9Ah (20 hour rate)
Dimensions	Total Height (with terminals)	66 mm (2.60 inches)
	Height	60 mm (2.36 inches)
	Length	177mm (6.97 inches)
	Width	34 mm (1.34 inches)
Weight		Approx. 700g (1.54 lbs)

■ Characteristics

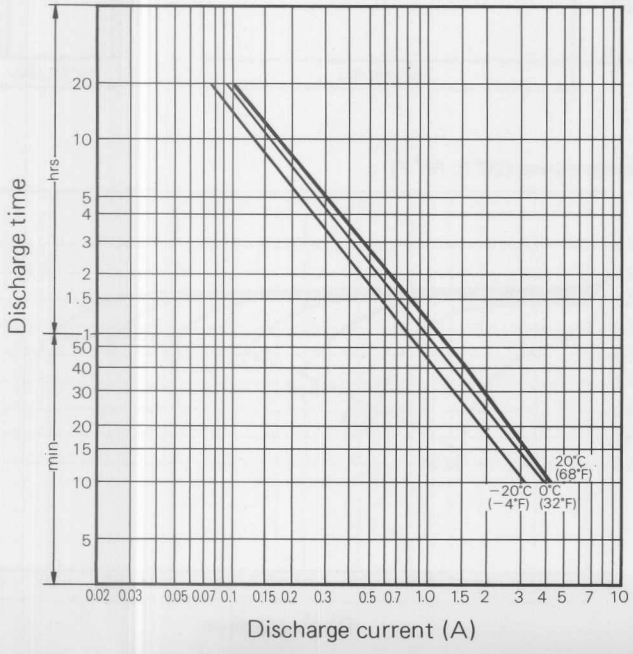
Capacity	20 hour rate (95mA) 10 hour rate (180mA) 5 hour rate (300mA) 1 hour rate (1100mA)	1.9Ah 1.8Ah 1.5Ah 1.1Ah
	1.5 hour discharge to 10.5V	0.85A
Internal Resistance	Full charged Battery (20°C, 68°F)	70mΩ
Capacity affected by Temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) –20°C (–4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Max. Discharge Current (20°C, 68°F)	60A (continuous)	
Terminal	AMP Faston type 187 Tab terminal	
Charge (Constant voltage) — Cycle	Initial Charging Current less than 0.76A Voltage 14.6–15.0V/12V 20°C (68°F)	
Charge (Constant voltage) — Float	Initial Charging Current less than 0.76A Voltage 13.6–13.8V/12V 20°C (68°F)	



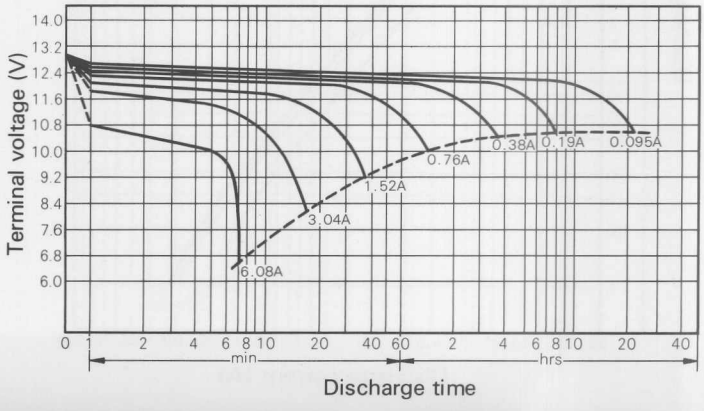
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)

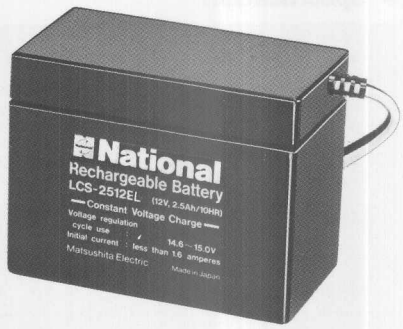


LCS-2512EL (NEW)

■ Specification

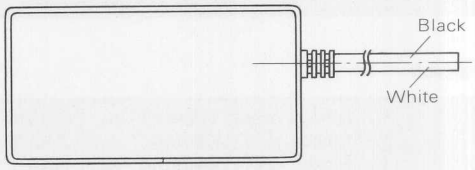
Nominal Voltage		12V
Nominal Capacity (20 hour rate)		2.7Ah
Dimensions	Total Height	80 mm (3.15 inches)
	Height	80 mm (3.15 inches)
	Length	102 mm (4.02 inches)
	Width	55.5 mm (2.19 inches)
Weight		Approx. 1200g (2.65 lbs)

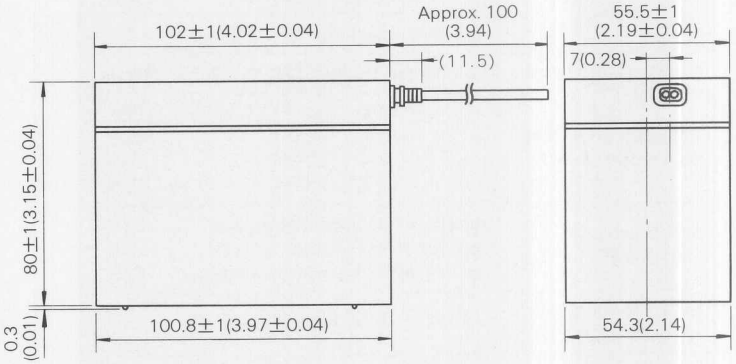
Note: Excellent for engine-start and power tools.



Wire: 2.0mm²
Other types may be used on special order.

Unit: mm(inch)

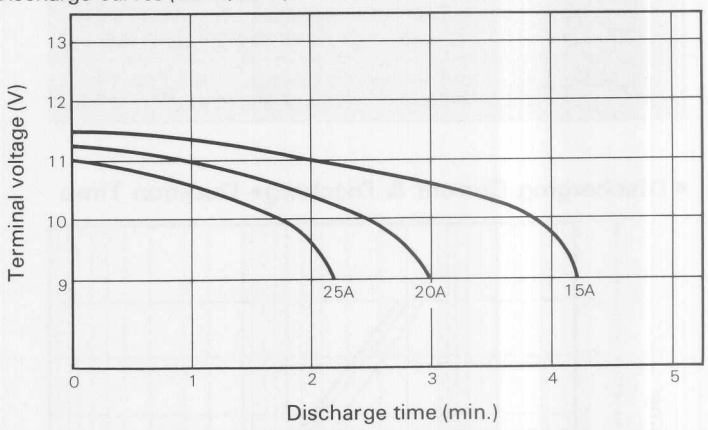




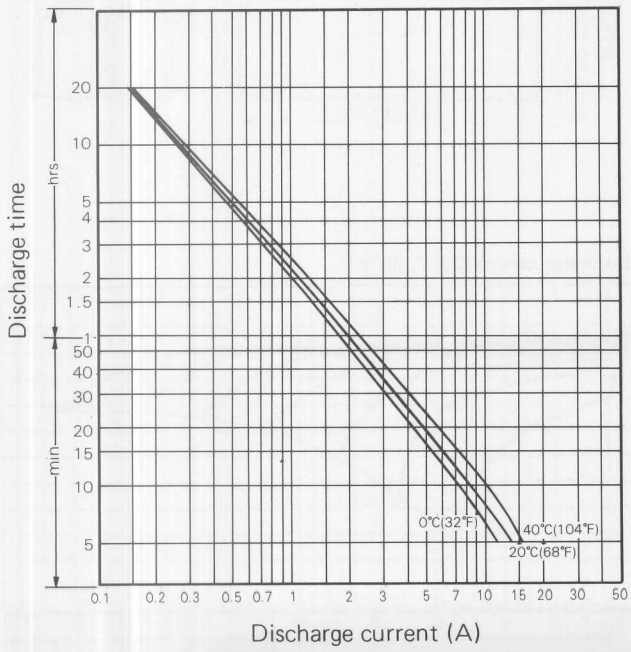
■ Characteristics

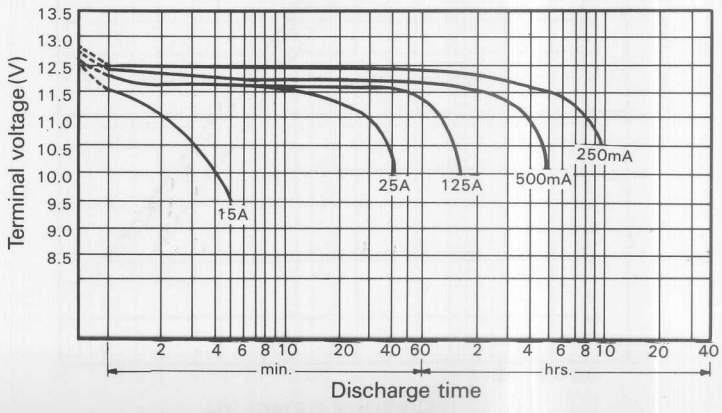
Capacity	20hour rate (135mA)	2.7 Ah
	10hour rate (250mA)	2.5 Ah
	5hour rate (470mA)	2.35Ah
	1hour rate (1900mA)	1.9 Ah
	1.5 hour discharge to 5.25V	1.4A
Internal Resistance	Full charged Battery (20°C,68°F)	40mΩ
Capacity affected by Temperature	40°C (104°F)	102%
	20°C (68°F)	100%
	0°C (32°F)	85%
	–20°C (–4°F)	60%
Self-Discharge (20°C,68°F)	Capacity after 3 month storage	90%
	Capacity after 6 month storage	80%
	Capacity after 12 month storage	60%
Maximum Discharge Current(20°C,68°F)	30A (continuous)	
Terminal	Wire leads	
Charge (Constant voltage) Cycle	Initial Charging Current less than 1.0A Voltage 14.6–15.0V/12V 20°C (68°F)	

Discharge curves (20°C,68°F)



■ Discharging Current & Discharge Duration Time

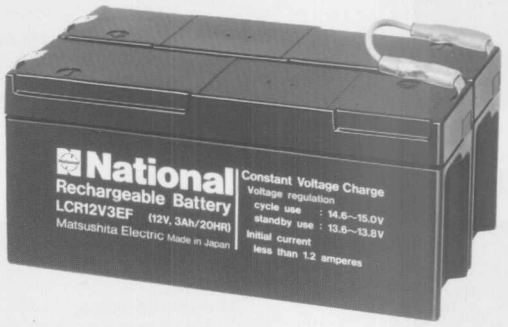




LCR 12V3EF

■ Specification

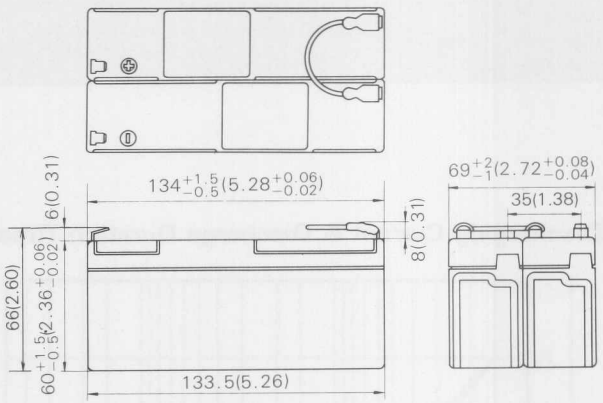
Nominal Voltage		12V
Nominal Capacity		3 Ah (20 hour rate)
Dimensions	Total Height (with terminals)	66 mm (2.60 inches)
	Height	60 mm (2.36 inches)
	Length	134 mm (5.28 inches)
	Width	69 mm (2.72 inches)
Weight		Approx. 550 g (1.21 lbs)



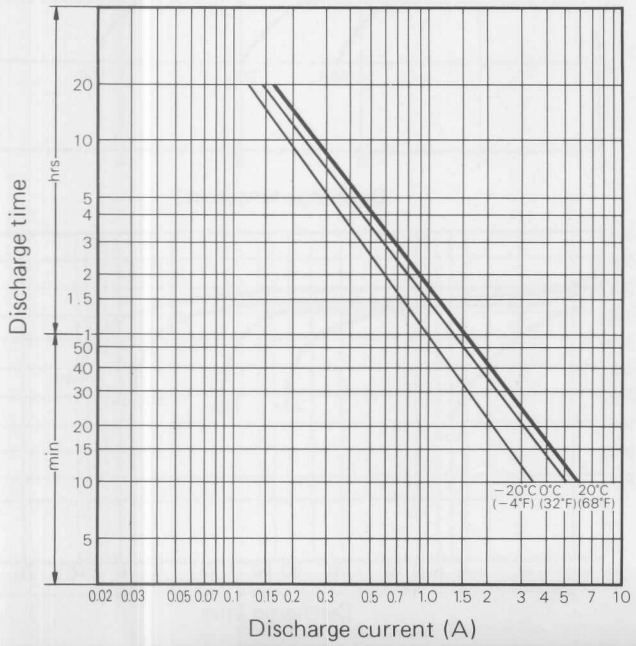
■ Characteristics

Capacity		20 hour rate (150mA) 10 hour rate (280mA) 5 hour rate (480mA) 1 hour rate (1800mA)	3.0Ah 2.8Ah 2.4Ah 1.8Ah
		1.5 hour discharge to 10.5V	1.3A
Internal Resistance		Full charged Battery (20°C, 68°F)	60mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Max. Discharge Current (20°C, 68°F)		60A (continuous)	
Terminal		AMP Faston type 187 Tab terminal	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 1.2A Voltage 14.6–15.0V/12V 20°C (68°F)	
	Float	Initial Charging Current less than 1.2A Voltage 13.6–13.8V/12V 20°C (68°F)	

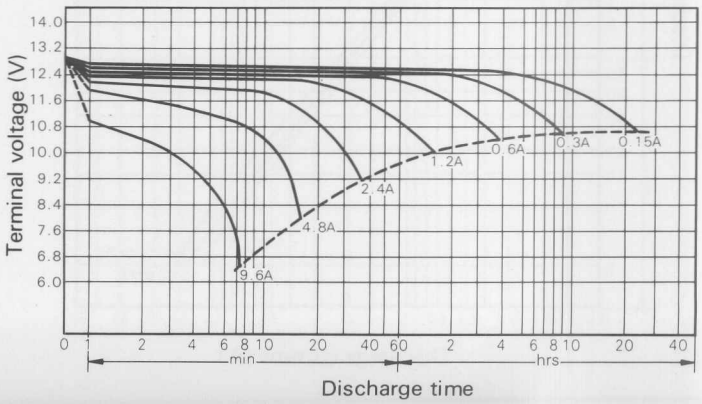
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR 12V6.5E (formerly LCR-6512E)

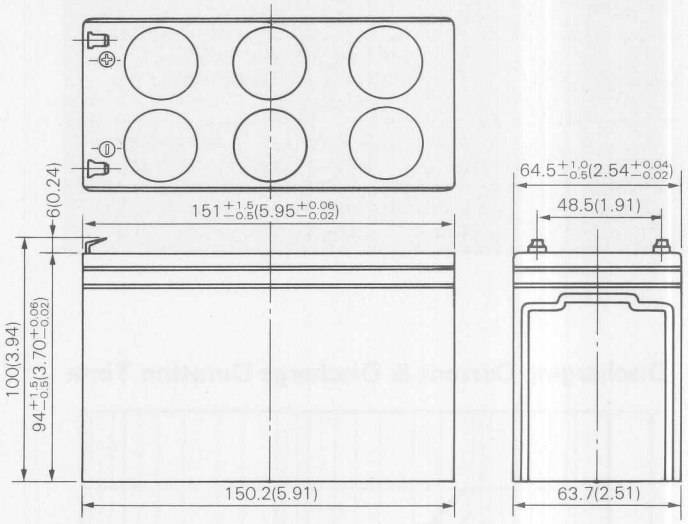
■ Specification

Nominal Voltage		12V
Nominal Capacity (20 hour rate)		6.5Ah
Dimensions	Total Height	100 mm (3.94 inches)
	Height	94 mm (3.70 inches)
	Length	151 mm (5.95 inches)
	Width	64.5 mm (2.54 inches)
Weight		2,200 g (4.85 lbs)

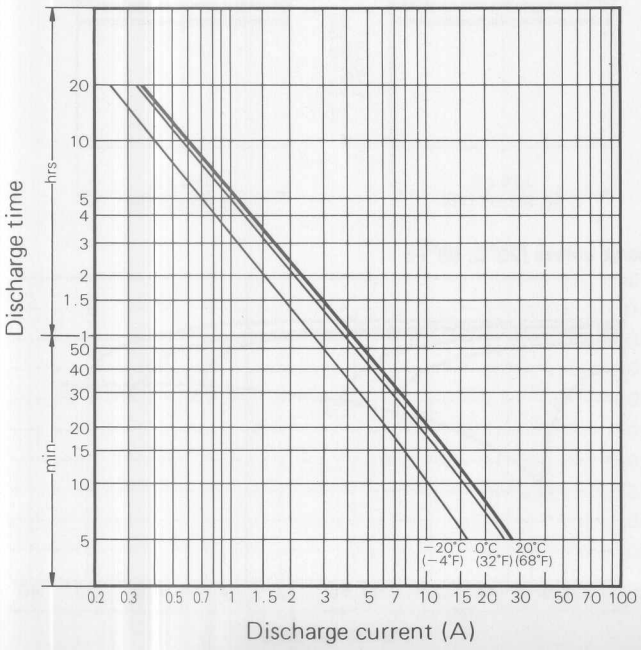
■ Characteristics

Capacity	20 hour rate (325mA) 10 hour rate (600mA) 5 hour rate (1040mA) 1 hour rate (4000mA)	6.5Ah 6.0Ah 5.2Ah 4.0Ah
	1.5 hour discharge to 5.25V	2.9A
Internal Resistance	Full charged Battery (20°C, 68°F)	40mΩ
Capacity affected by Temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Maximum Discharge Current (20°C, 68°F)	80A (Continuous)	
Terminal — Standard	LCR 12V6.5E AMP Faston type 187	
Terminal — Optional	LCR 12V6.5E-1 AMP Faston type 250	
Charge (Constant voltage) — Cycle	Initial Charging Current less than 2.6A Voltage 14.6–15.0V/12V 20°C (68°F)	
Charge (Constant voltage) — Float	Initial Charging Current less than 2.6A Voltage 13.6–13.8V/12V 20°C (68°F)	

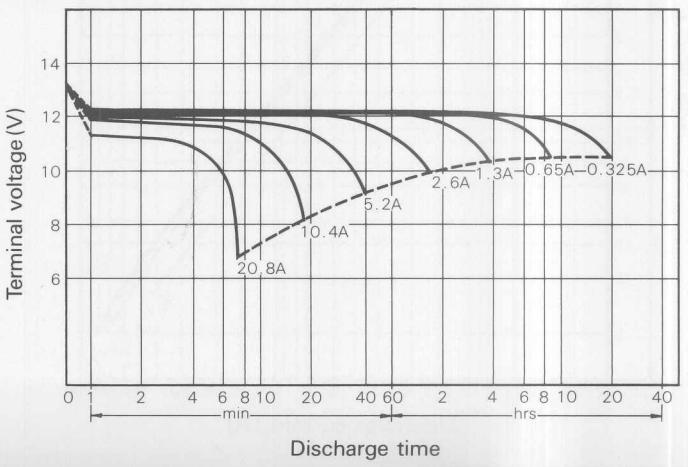
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR12V24E (formerly LCR-24012E)

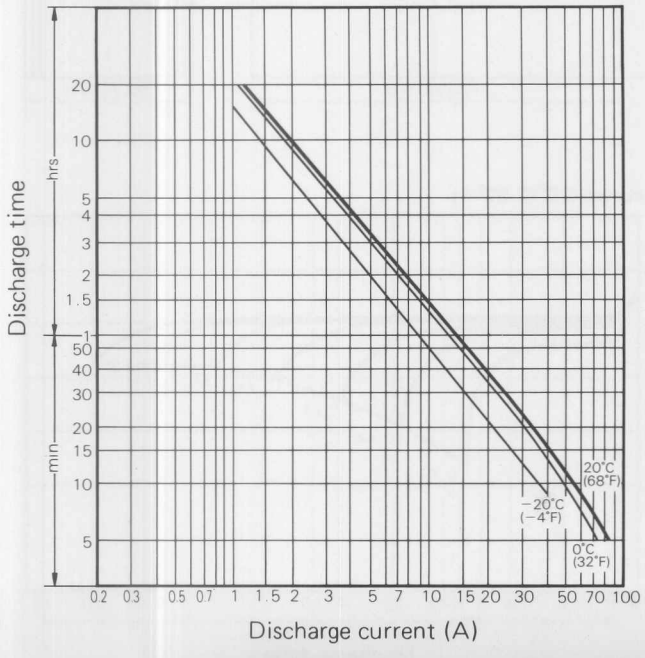
■ Specification

Nominal Voltage		12V
Nominal Capacity (20hour rate)		24Ah
Dimensions	Total Height	125mm (4.92 inches)
	Length	175mm (6.89 inches)
	Width	165mm (6.50 inches)
Weight		Approx. 8.7kg (19.2 lbs)

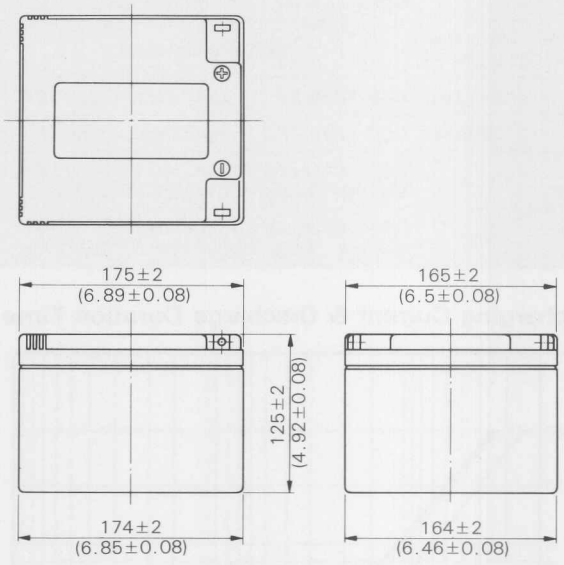
■ Characteristics

Capacity		20 hour rate (1.2A) 10 hour rate (2.2A) 5 hour rate (3.8A) 1 hour rate (14.0A)	24Ah 22Ah 19Ah 14Ah
		1.5 hour discharge to 10.5V	9.8A
Internal Resistance		Full charged Battery (20°C, 68°F)	15mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		M5 Bolt and Nut Type Note: Comes with AMP first-on adaptor kit.	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 9.5A Voltage 14.6–15.0V/12V 20°C (68°F)	
	Trickle	Initial Charging Current less than 9.5A Voltage 13.6–13.8V/12V 20°C (68°F)	

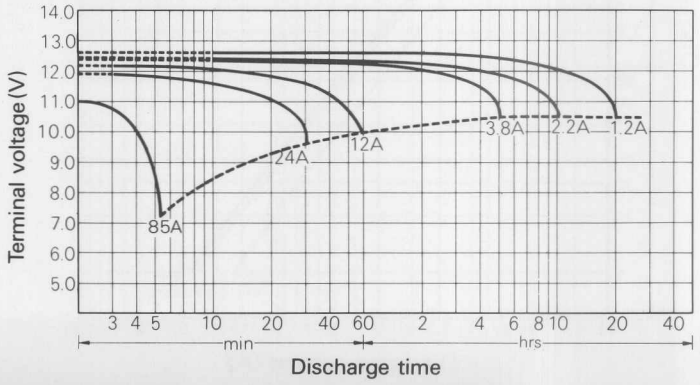
■ Discharging Current & Discharge Duration Time



Unit: mm (inch)



Discharge curves (20°C, 68°F)



LCL 12V38E (NEW)

■ Specification

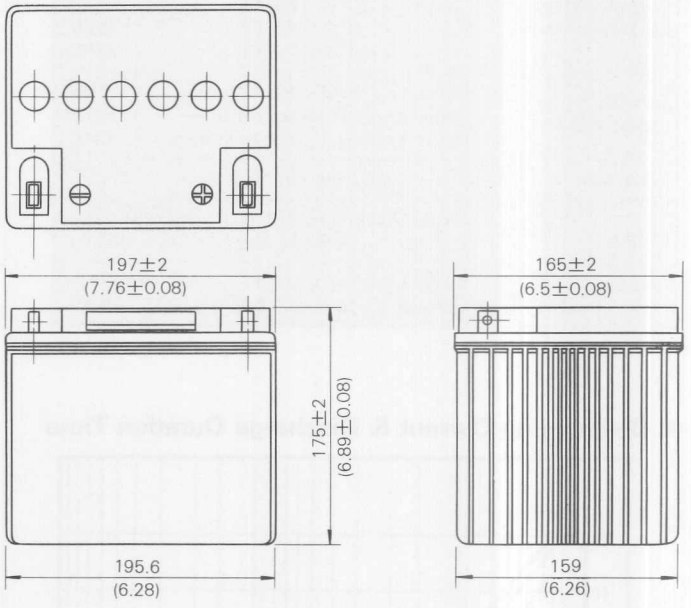
Nominal Voltage		12V
Nominal Capacity (20hour rate)		38Ah
Dimensions	Total Height	175 mm (6.89 inches)
	Height	175 mm (6.89 inches)
	Length	197 mm (7.76 inches)
	Width	165 mm (6.50 inches)
Weight		Approx. 13.0 kg (31.3 lds.)

Note: High rate capability. Excellent for UPS systems and wheel chairs.

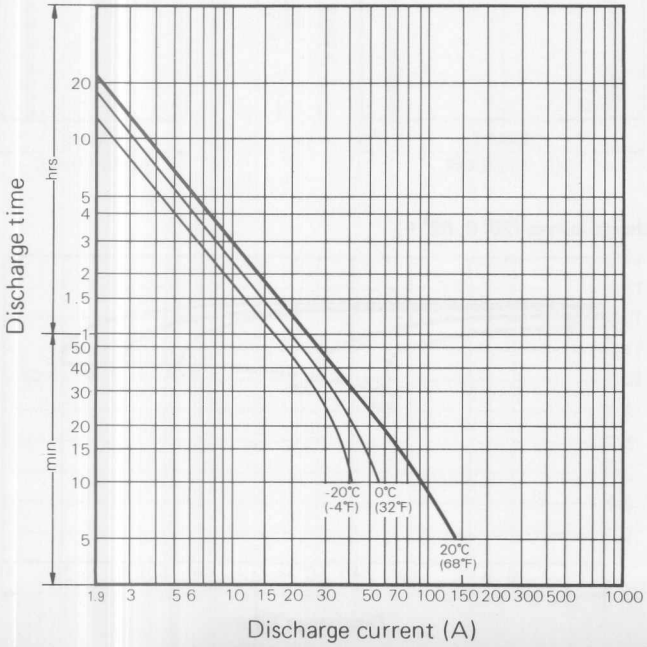
■ Characteristics

Capacity		20 hour rate (1.9A) 10 hour rate (3.5A) 5 hour rate (6.3A) 1 hour rate (22.5A)	38.0Ah 35.0Ah 31.5Ah 22.5Ah
		1.5 hour discharge to 10.5V	15.5A
Internal Resistance		Full charged battery (20°C, 68°F)	8mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) –20°C (–4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		M6 Bolt and Nut Type	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 14A Voltage 14.6–15.0V/12V 20°C(68°F)	
	Float	Initial Charging Current less than 14A Voltage 13.6–13.8V/12V 20°C(68°F)	

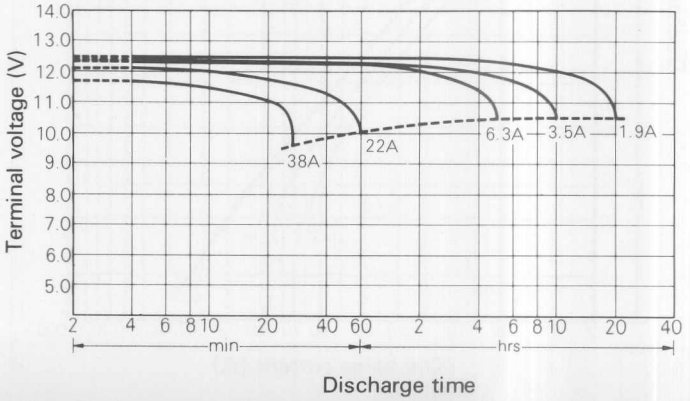
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR12V60E (formerly LCR-60012E)

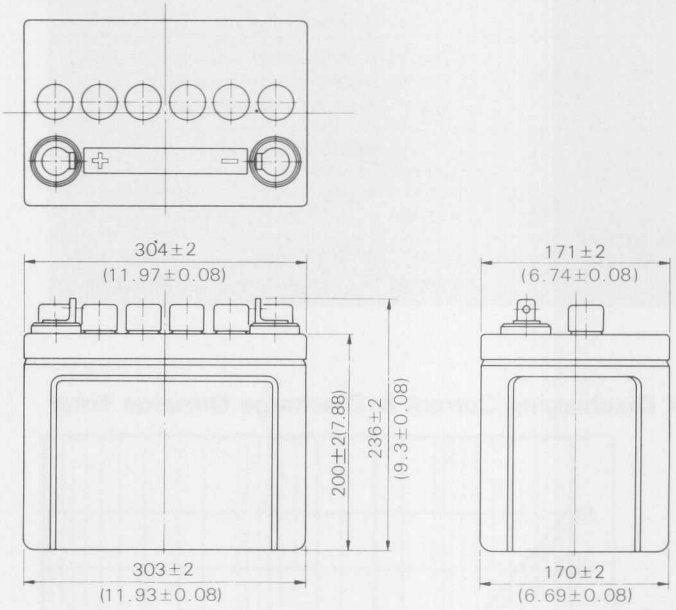
■ Specification

Nominal Voltage		12V
Nominal Capacity (20hour rate)		60Ah
Dimensions	Total Height (with terminals)	236mm (9.3 inches)
	Length	304mm (11.97 inches)
	Width	171mm (6.74 inches)
Weight		Approx. 24kg (52.9 lbs)

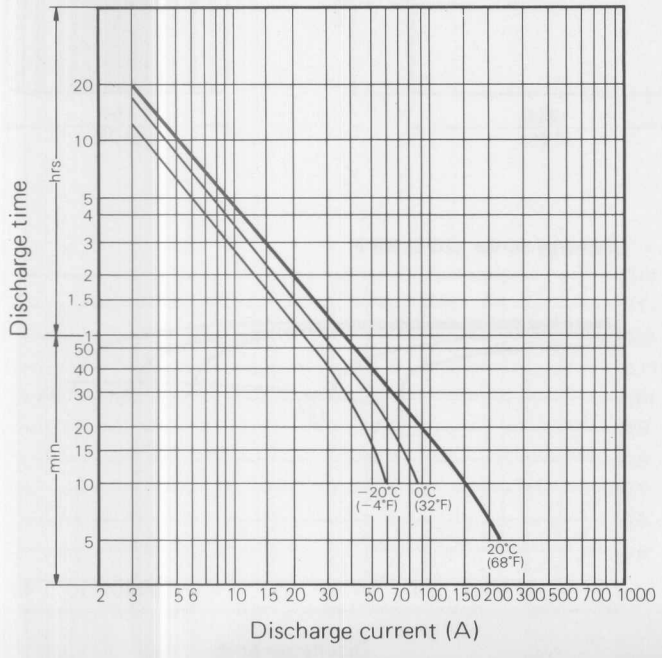
■ Characteristics

Capacity		20 hour rate (3.0A) 10 hour rate (5.2A) 5 hour rate (9.0A) 1 hour rate (34A)	60Ah 52Ah 45Ah 34Ah
		1.5 hour discharge to 10.5V	26A
Internal Resistance		Full charged Battery (20°C, 68°F)	6mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		M6 Bolt and Nut Type	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 24A Voltage 14.6–15.0V/12V 20°C (68°F)	
	Float	Initial Charging Current less than 24A Voltage 13.6–13.8V/12V 20°C (68°F)	

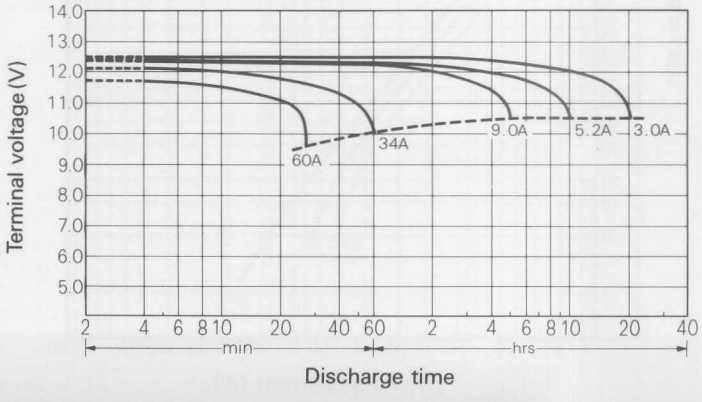
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR12V80E

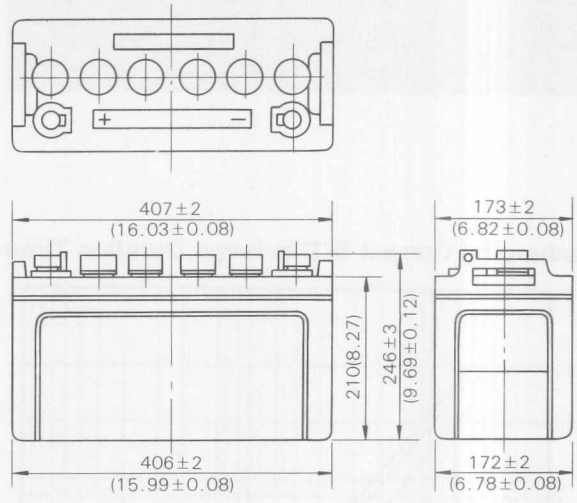
■ Specification

Nominal Voltage		12V
Nominal Capacity (20hour rate)		80Ah
Dimensions	Total Height (with terminals)	246mm (9.69 inches)
	Length	407mm (16.03 inches)
	Width	173mm (6.82 inches)
Weight		Approx. 36kg (80 lbs)

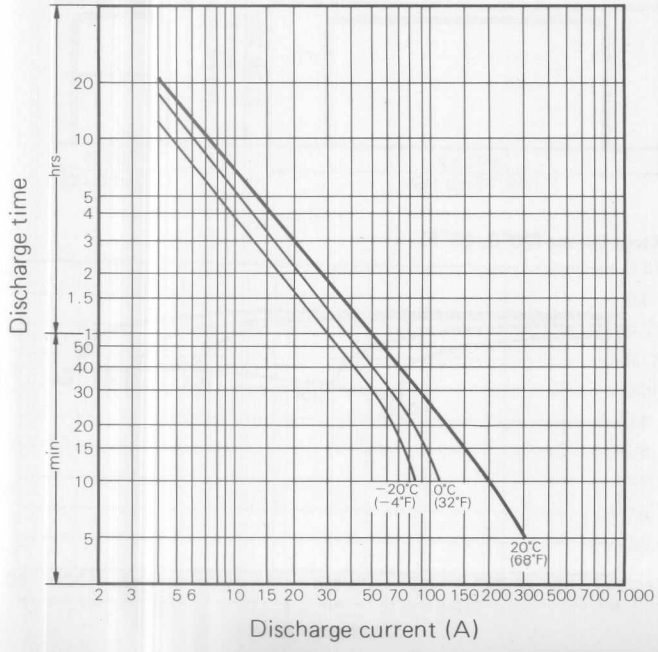
■ Characteristics

Capacity		20 hour rate (4.0A) 10 hour rate (7.0A) 5 hour rate (12.0A) 1 hour rate (45.0A)	80Ah 70Ah 60Ah 45Ah
		1.5 hour discharge to 10.5V	34A
Internal Resistance		Full charged Battery (20°C,68°F)	4.5mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		M8 Bolt and Nut Type	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 32A Voltage 14.6–15.0V/12V 20°C (68°F)	
	Float	Initial Charging Current less than 32A Voltage 13.6–13.8V/12V 20°C (68°F)	

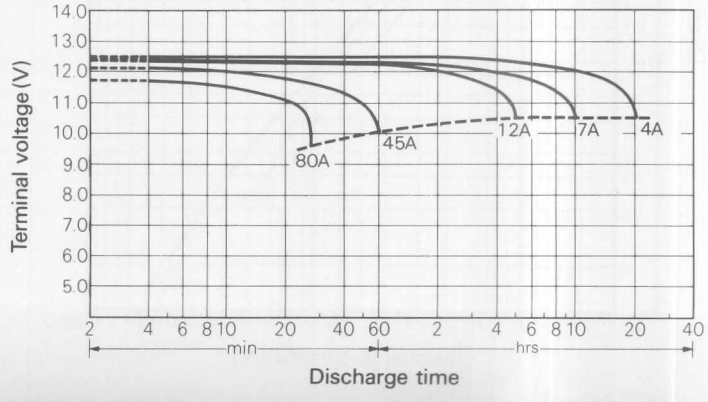
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR12V100E

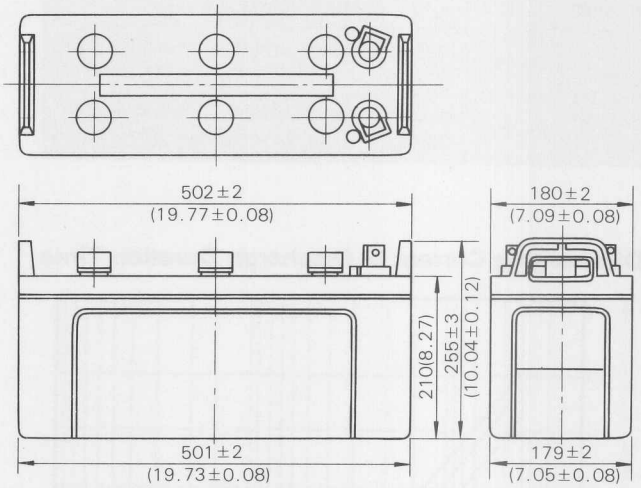
■ Specification

Nominal Voltage		12V
Nominal Capacity (20hour rate)		100Ah
Dimensions	Total Height	255mm (10.04 inches)
	Length	502mm (19.77 inches)
	Width	180mm (7.09 inches)
Weight		Approx. 45kg (100 lbs)

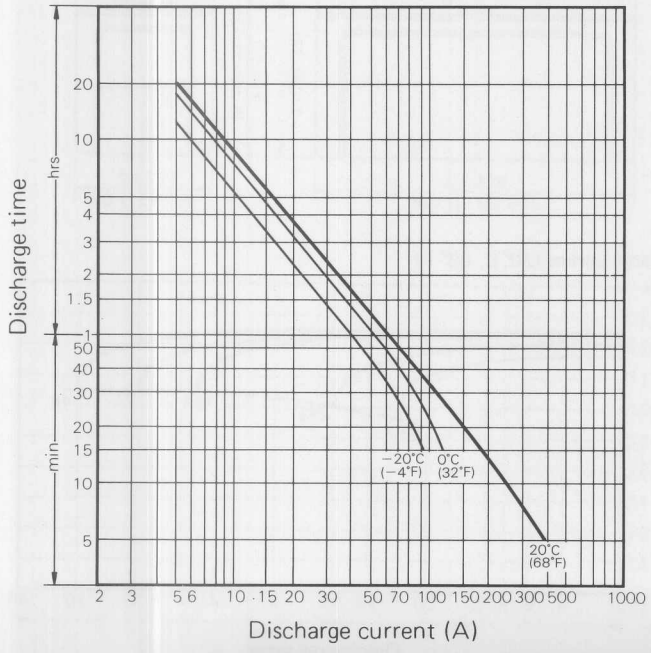
■ Characteristics

Capacity		20 hour rate (5.0A) 10 hour rate (8.6A) 5 hour rate (15.0A) 1 hour rate (56.0A)	100Ah 86Ah 75Ah 56Ah
		1.5 hour discharge to 10.5V	43A
Internal Resistance		Full charged Battery (20°C,68°F)	3.5mΩ
Capacity affected by Temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		M8 Bolt and Nut Type	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 40A Voltage 14.6–15.0V/12V 20°C (68°F)	
	Float	Initial Charging Current less than 40A Voltage 13.6–13.8V/12V 20°C (68°F)	

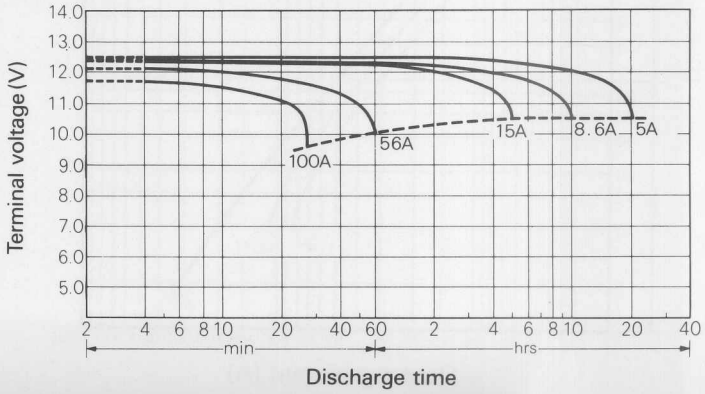
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCR12V120E

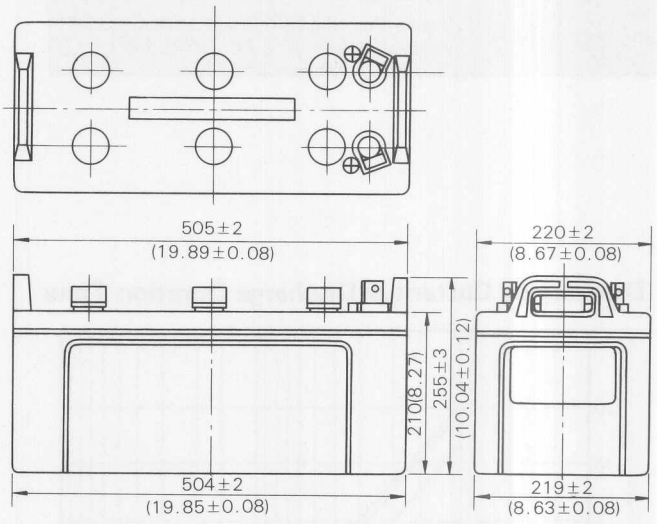
■ Specification

Nominal Voltage		12V
Nominal Capacity (20hour rate)		120Ah
Dimensions	Total Height	255mm (10.04 inches)
	Length	505mm (19.89 inches)
	Width	220mm (8.67 inches)
Weight		Approx. 52kg (115 lbs)

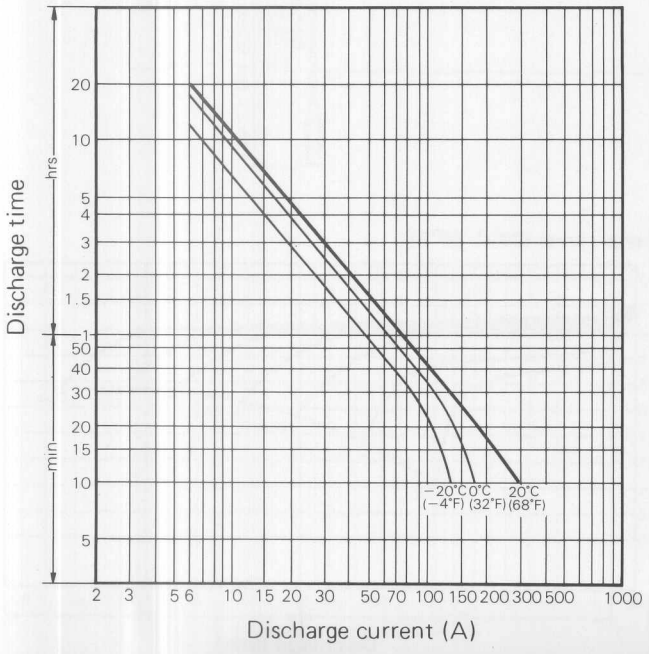
■ Characteristics

Capacity	20 hour rate (6.0A) 10 hour rate (10.4A) 5 hour rate (18.0A) 1 hour rate (68.0A)	120Ah 104Ah 90Ah 68Ah
	1.5 hour discharge to 5.25V	50A
Internal Resistance	Full charged Battery (20°C,68°F)	3mΩ
Capacity affected by Temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal	M8 Bolt and Nut Type	
Charge (Constant voltage) Cycle	Initial Charging Current less than 48A Voltage 14.6–15.0V/12V 20°C (68°F)	
Charge (Constant voltage) Float	Initial Charging Current less than 48A Voltage 13.6–13.8V/12V 20°C (68°F)	

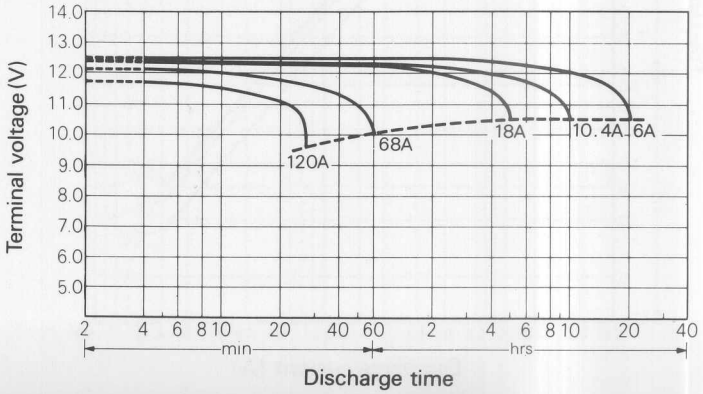
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



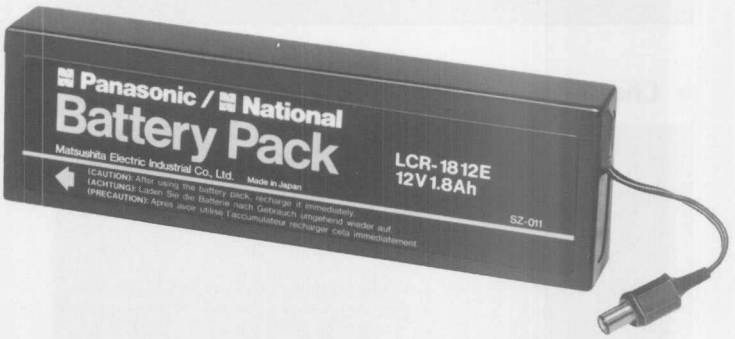
Discharge curves (20°C, 68°F)



LCR-1812E

■ Specification

Nominal Voltage		12V
Nominal Capacity		1.8Ah (10 hour rate)
Dimensions	Total Height	60.5 mm (2.38 inches)
	Length	200.5 mm (7.89 inches)
	Width	24.8 mm (0.98 inches)
Weight		Approx. 700 g (1.54 lbs)

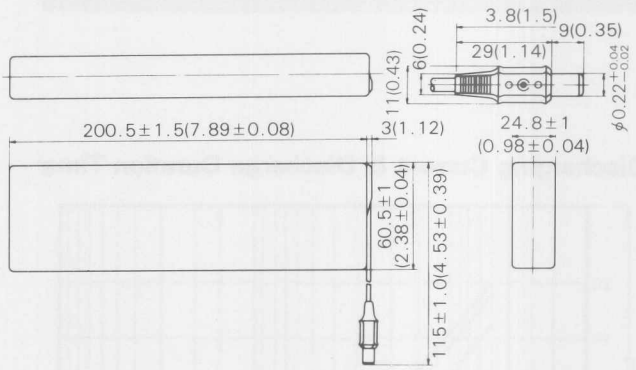


■ Characteristics

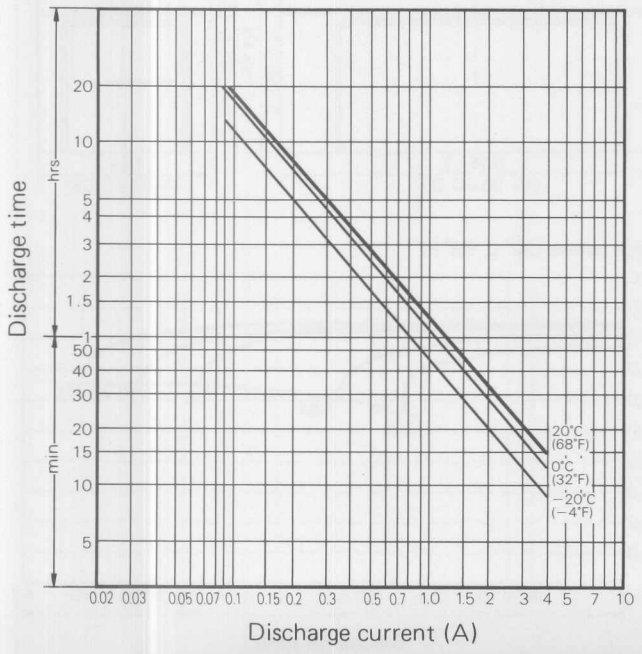
Capacity	20 hour rate (95mA) 10 hour rate (180mA) 5 hour rate (320mA) 1 hour rate (1,200mA)	1.9Ah 1.8Ah 1.6Ah 1.2Ah
	1.5 hour discharge to 10.5V	0.85A
Internal Resistance	Full charged Battery (20°C, 68°F)	180mΩ
Capacity affected by temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	89% 77% 54%
Terminal	DC PLUG	
Charge (Constant voltage) Cycle	Initial Charging Current : less than 0.72A Voltage : 14.6–15.0V at 20°C (68°F)	

Connector: I/D = $3.0^{+0.1}_{-0}$ ($0.118^{+0.004}_{-0}$)

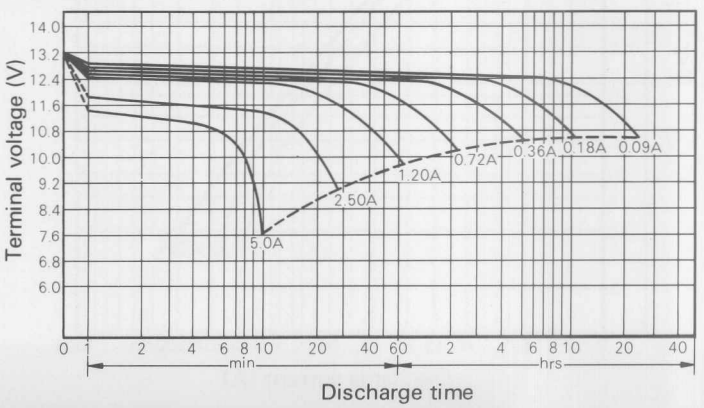
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCS-2012AE (NEW)

■ Specification

Nominal Voltage		12V
Nominal Capacity		2.0Ah (10 hour rate)
Dimensions	Total Height	61.7 mm (2.43 inches)
	Length	182 mm (7.165 inches)
	Width	23.85 mm (0.939 inches)
Weight		Approx. 635 g (1.40 lbs)

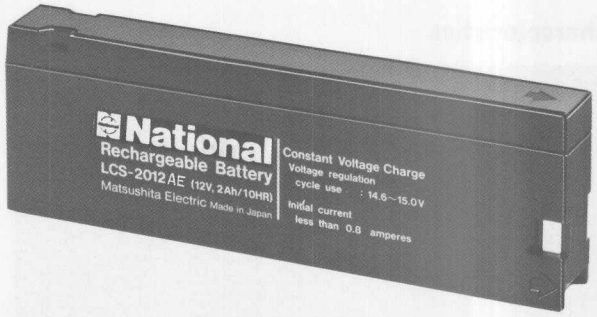
■ Characteristics

Capacity	20 hour rate (103mA) 10 hour rate (200mA) 5 hour rate (340mA) 1 hour rate (1,250mA)	2.05Ah 2.0 Ah 1.7 Ah 1.25Ah
	1.5 hour discharge to 10.5V	0.9A
Internal Resistance	Full charged battery (20°C, 68°F)	120mΩ
Capacity affected by temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	102% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	90% 80% 60%
Terminal	Pressure contact	
Charge (Constant voltage) Cycle	Initial Charging Current : less than 0.8A Voltage : 14.6–15.0V at 20°C(68°F)	

Note : Not designed for float service.

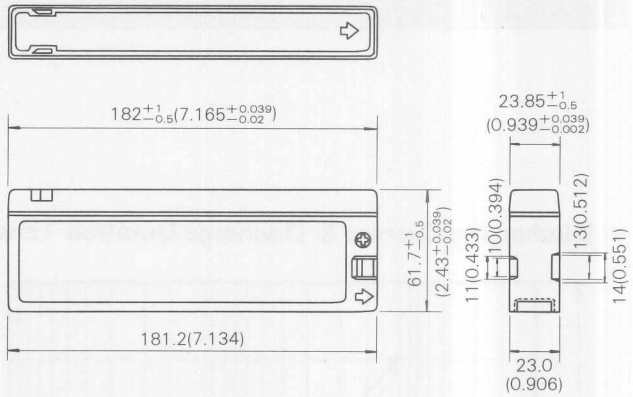
Note: Ideal for medical equipment and computers. VTR replacement battery.

1. Quick Charge Type
   (1~1.5 Hours Charge can be done with Specified Charger)
2. Built-in auto-reset Fuse
   OFF : 65 ± 5°C (149 ± 9°F)
   ON : 58 ± 5°C (104.4 ± 9°F)
3. Easy connection via pressure contacts

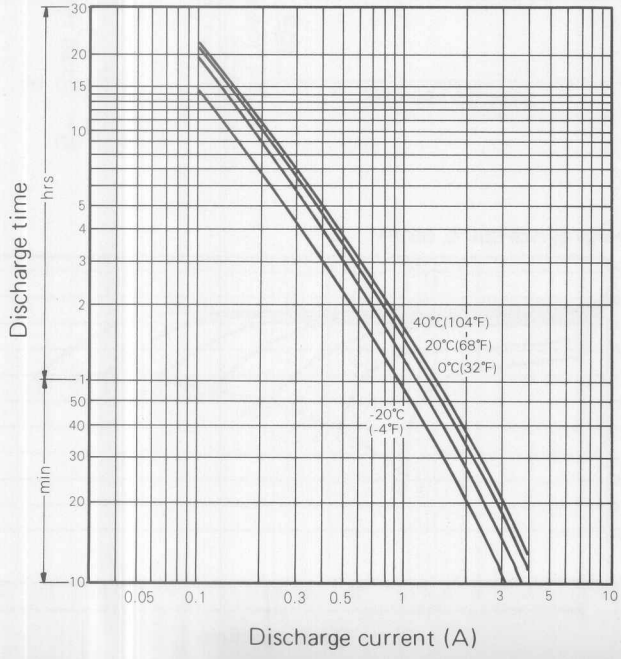


Mating Connector
Parts Number
VJA0180
Available

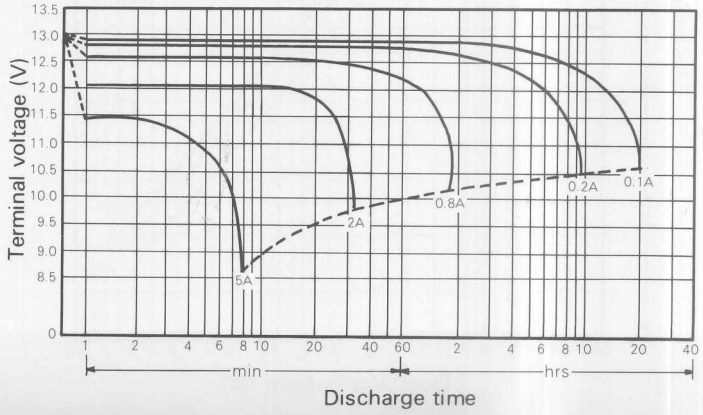
Unit: mm(inch)



■ Discharging Current & Discharge Duration Time



Discharge curves (20°C, 68°F)



LCS-2012E

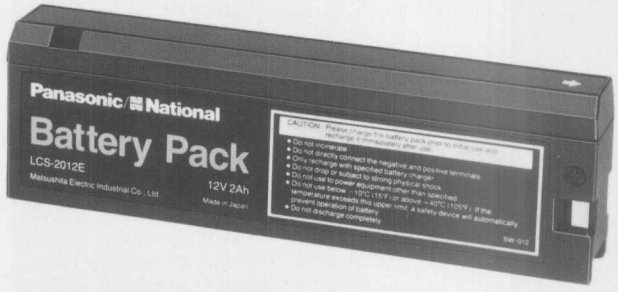
■ Specification

Nominal Voltage		12V
Nominal Capacity		2.0Ah (10 hour rate)
Dimensions	Total Height	61.8 mm (2.43 inches)
	Length	200.7 mm (7.90 inches)
	Width	24.8 mm (0.98 inches)
Weight		Approx. 1.54 lbs (700 g)

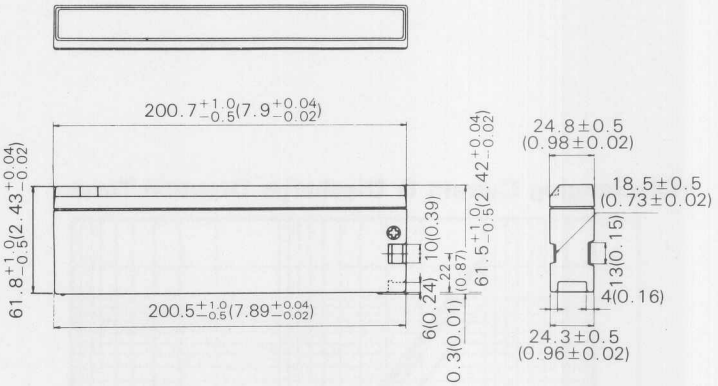
1. Quick Charge Type
   (1~1.5 Hours Charge can be done with Specified Charger)
2. Built-in auto-reset Fuse
   OFF : 65 ± 5°C (149 ± 9°F)
   ON : 58 ± 5°C (104.4 ± 9°F)
3. Easy connection via pressure contacts

■ Characteristics

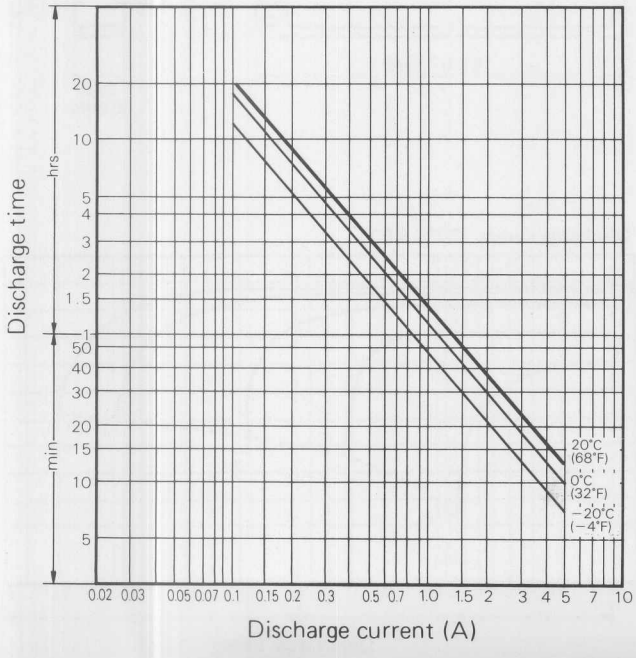
Capacity	20 hour rate (105mA) 10 hour rate (200mA) 5 hour rate (360mA) 1 hour rate (1,350mA)	2.1Ah 2.0Ah 1.8Ah 1.35Ah
	1.5 hour discharge to 10.5V	0.94A
Internal Resistance	Full charged Battery (20°C,68°F)	110mΩ
Capacity affected by temperature	40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)	Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	89% 77% 54%
Terminal	Pressure contact	
Charge (Constant voltage) Cycle	Initial Charging Current : less than 0.72A Voltage : 14.6–15.0V at 20°C (68°F)	



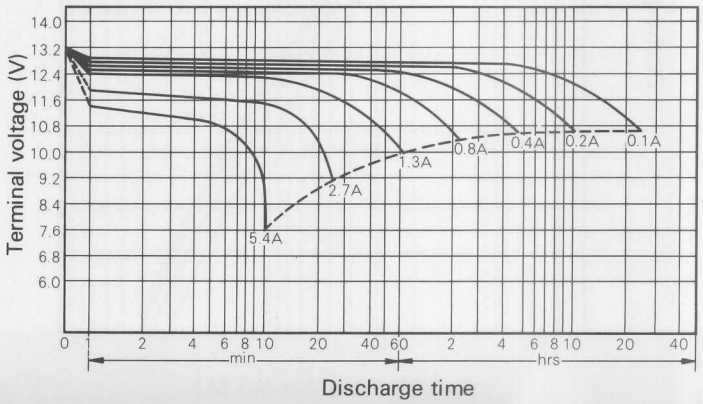
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



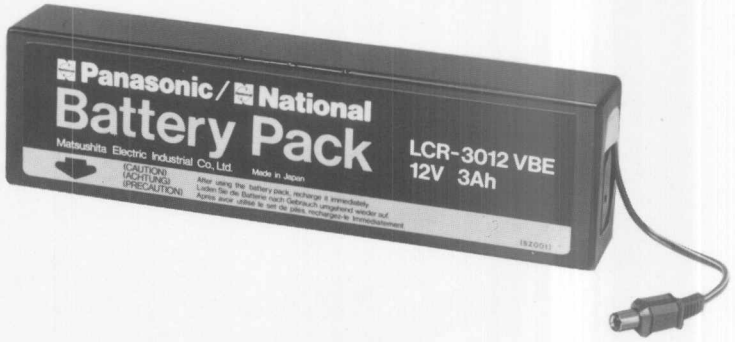
Discharge curves (20° C, 68° F)



LCR-3012VBE

■ Specification

Nominal Voltage		12V
Nominal Capacity		3.2Ah (20 hour rate)
Dimensions	Total Height	67mm (2.64 inches)
	Length	240mm (9.45 inches)
	Width	34mm (1.34 inches)
Weight		Approx 1,320g (2.91 lbs)

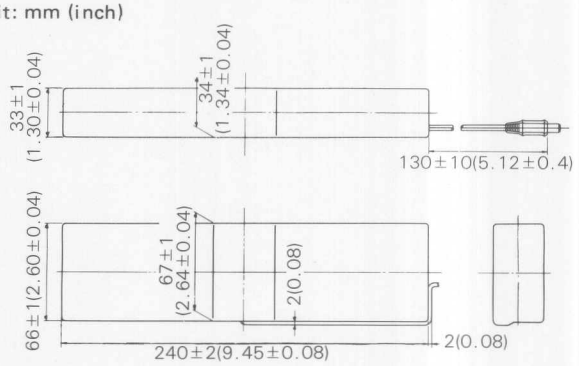


■ Characteristics

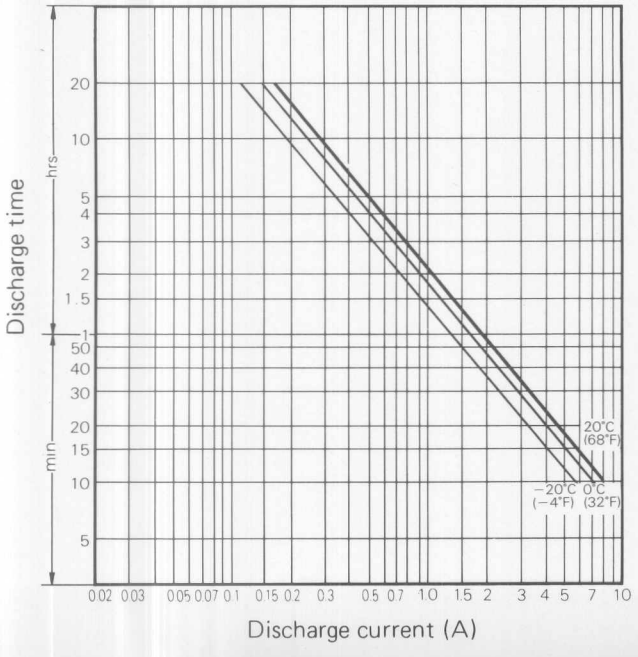
Capacity		20 hour rate (160mA) 10 hour rate (300mA) 5 hour rate (560mA) 1 hour rate (2,000mA)	3.2Ah 3.0Ah 2.8Ah 2.0Ah
		1.5 hour discharge to 10.5V	1.3A
Internal Resistance		Full charged Battery (20°C, 68°F)	80mΩ
Capacity affected by temperature		40°C (104°F) 20°C (68°F) 0°C (32°F) −20°C (−4°F)	105% 100% 85% 60%
Self-Discharge (20°C, 68°F)		Capacity after 3 month storage Capacity after 6 month storage Capacity after 12 month storage	91% 82% 64%
Terminal		DC PLUG	
Charge (Constant voltage)	Cycle	Initial Charging Current less than 1.2A Voltage 14.6–15.0V/12V 20°C (68°F)	
	Trickle	Initial Charging Current less than 1.2A Voltage 13.6–13.8V/12V 20°C (68°F)	

Connector: I/D = $3.0^{+0.1}_{-0}$
($0.118^{+0.004}_{-0}$)

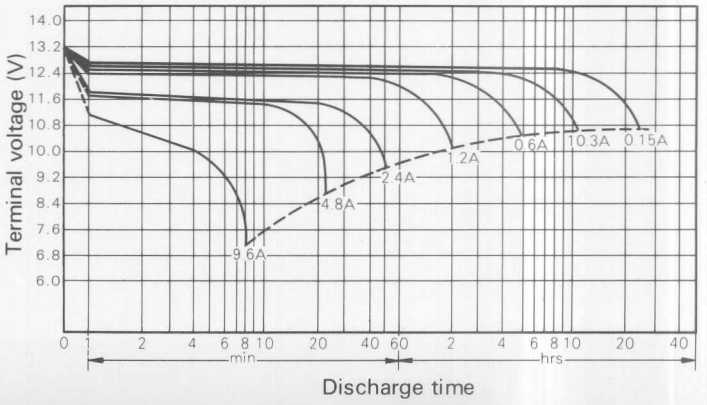
Unit: mm (inch)



■ Discharging Current & Discharge Duration Time



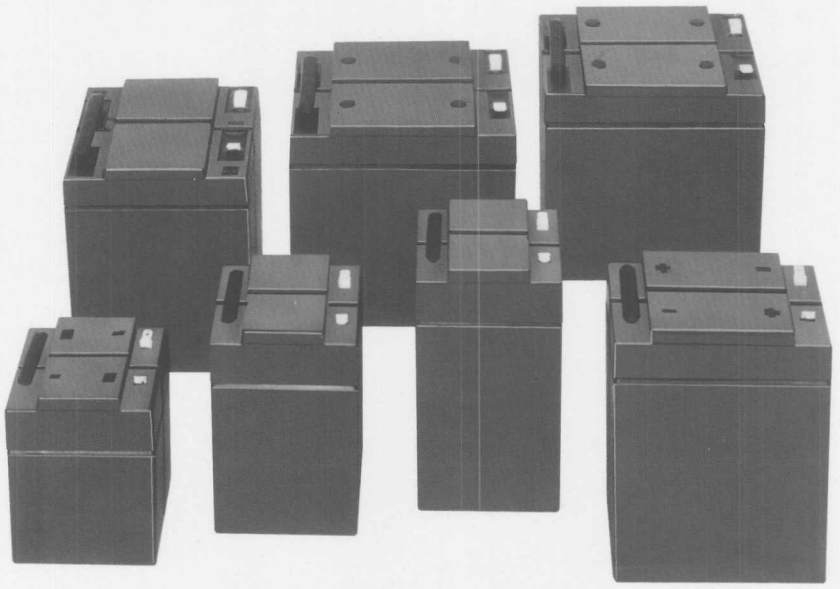
Discharge curves (20°C, 68°F)



4. Battery Assemblies

Many National LCR batteries can be assembled into 12 or 24 volt configurations. Some examples are shown here. For assistance, or if your needs are not shown, please contact National.

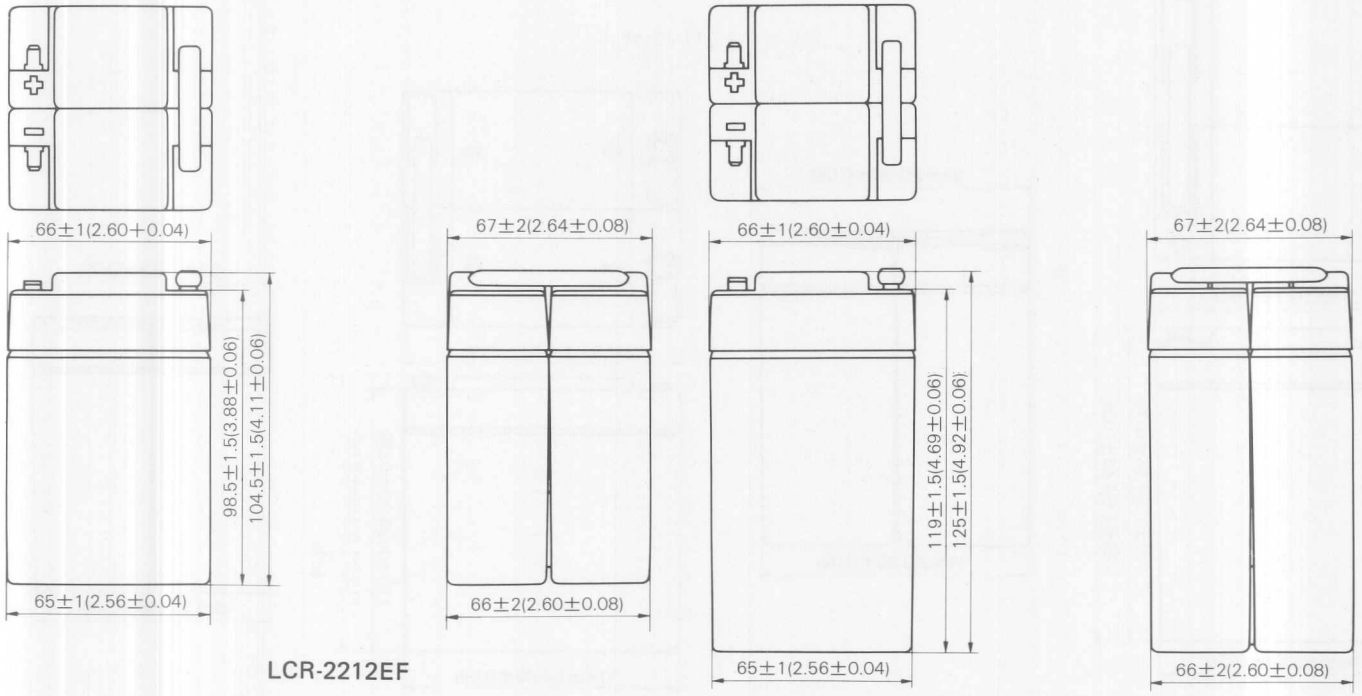
12V Battery Assemblies (F type)



■ Specification

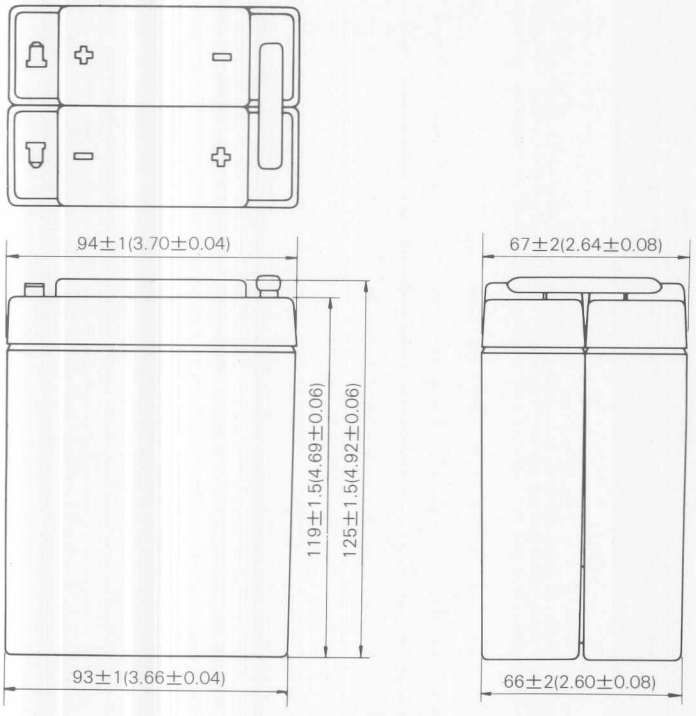
Model No.	Nominal Voltage (V)	Nominal Capacity at 20 hour rate (Ah)	Dimensions			Weight g (lbs)	Connection terminals
			Length mm (inch)	Width mm (inch)	Height mm (inch)		
LCR-2212 E F	12	2.4	66 (2.60)	67 (2.64)	104.5 (4.11)	1040 (2.29)	Type 187
LCR-3012 E F	12	3.2	66 (2.60)	67 (2.64)	125 (4.92)	1320 (2.91)	
LCR-4512 E F	12	4.8	94 (3.70)	67 (2.64)	125 (4.92)	1850 (4.80)	
LCR-6012 E F	12	6.4	91 (3.58)	99 (3.90)	115 (4.53)	2400 (5.29)	Type 250
LCR-8512 E F	12	9.2	115 (4.53)	99 (3.90)	115 (4.53)	3200 (7.05)	

12V Battery Assemblies (F type)



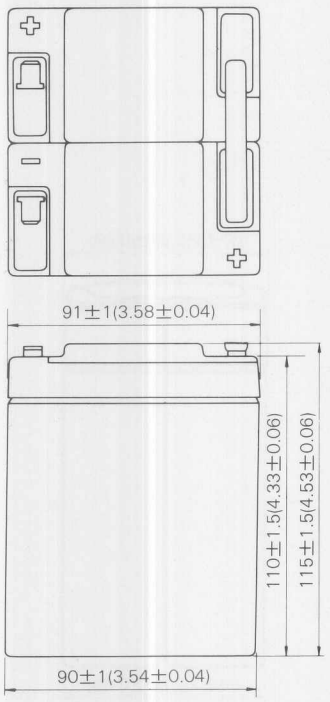
LCR-2212EF

LCR-3012EF

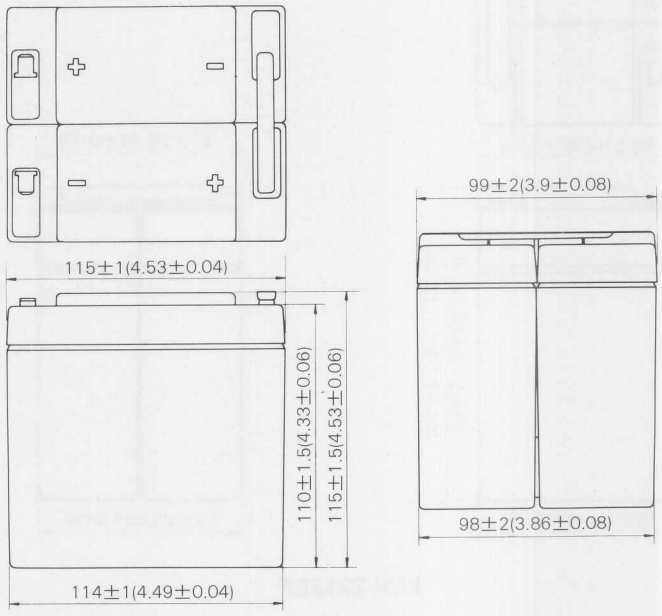


LCR-4512EF

12V Battery Assemblies (F type)

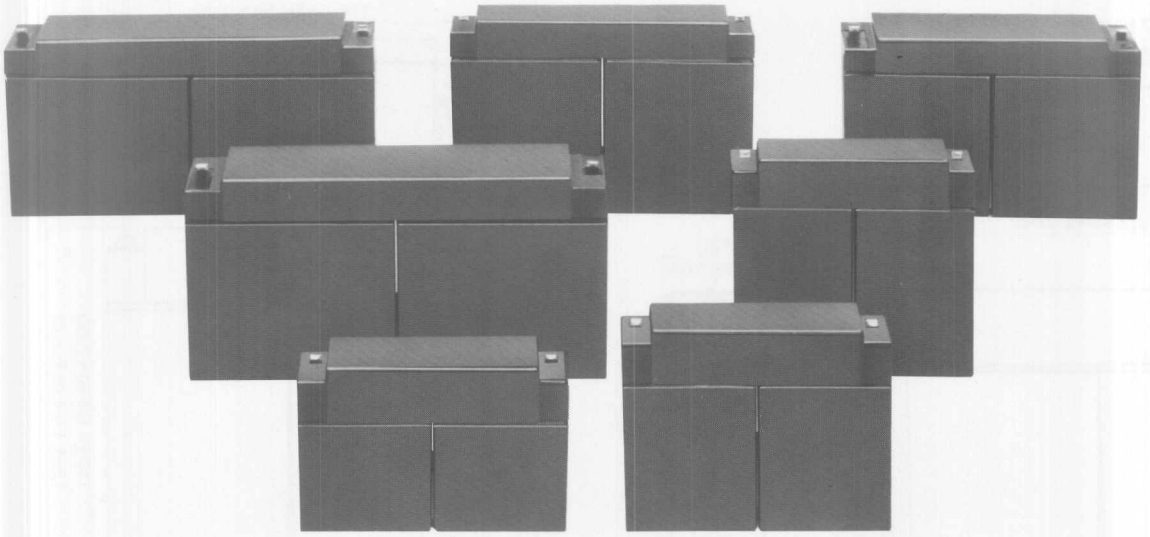


LCR-6012EF



LCR-8512EF

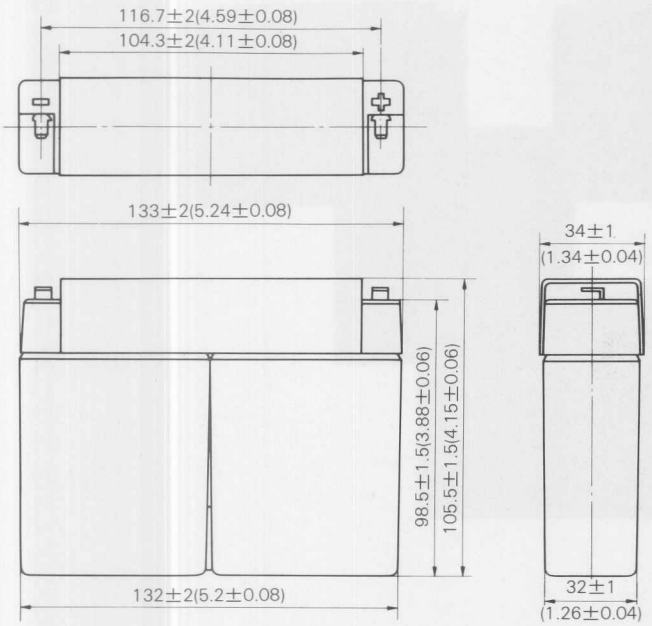
12V Battery Assemblies (S type)



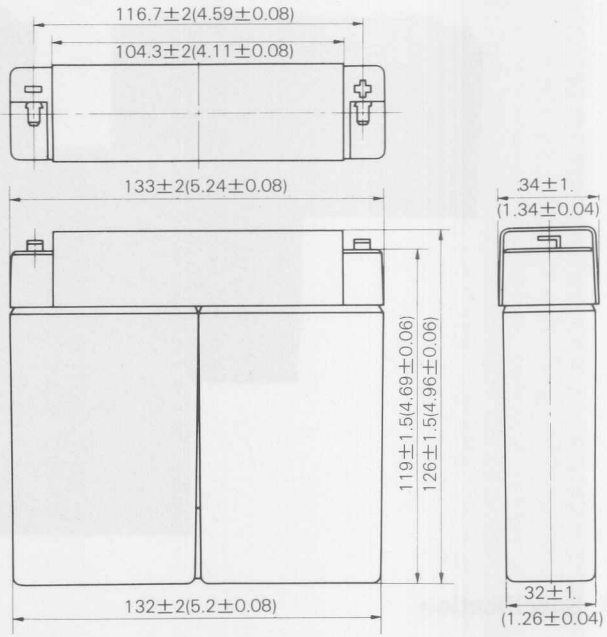
■ Specification

Model No.	Nominal Voltage (V)	Nominal Capacity at 20 hour rate (Ah)	Dimensions			Weight g (lbs)	Connection terminals
			Length mm (inch)	Width mm (inch)	Height mm (inch)		
LCR-2212 ES	12	2.4	133 (5.24)	34 (1.34)	105.5 (4.15)	1050 (2.31)	Type 250
LCR-3012 ES	12	3.2	133 (5.24)	34 (1.34)	126 (4.96)	1330 (2.93)	
LCR-4512 ES	12	4.8	189 (7.44)	34 (1.34)	126 (4.96)	1850 (4.08)	
LCR-6012 ES	12	6.4	183 (7.20)	50 (1.97)	116 (4.57)	2400 (5.29)	Type 187
LCR-8512 ES	12	9.2	231 (9.09)	50 (1.97)	116 (4.57)	3200 (7.05)	

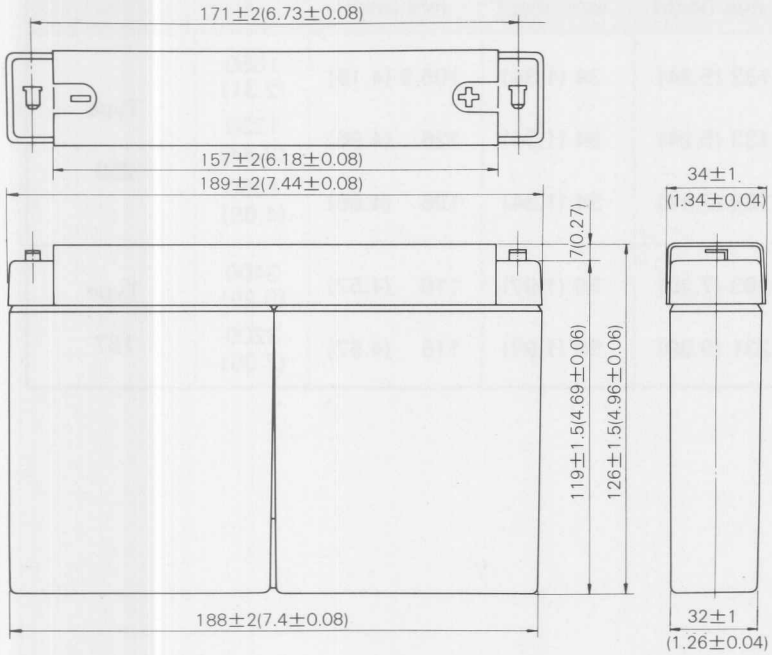
12V Battery Assemblies (S type)



LCR-2212ES

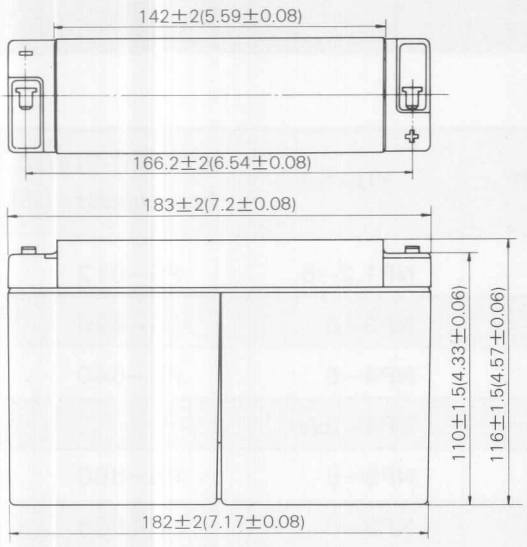


LCR-3012ES

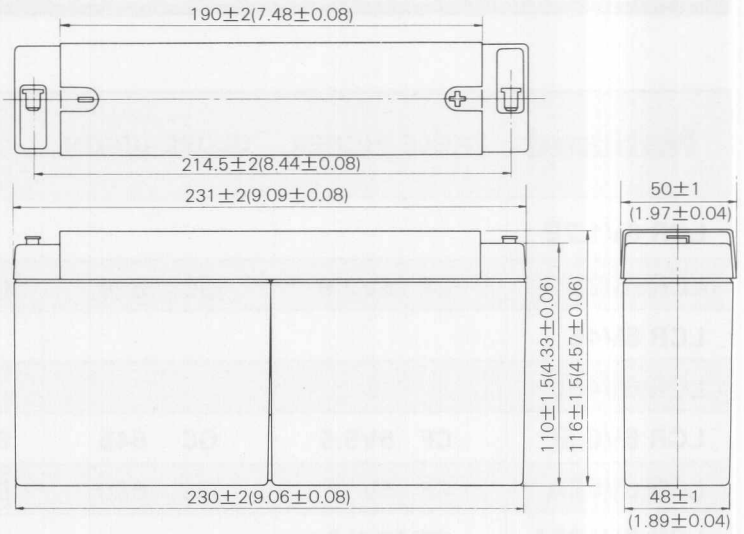


LCR-4512ES

12V Battery Assemblies (S type)



LCR-6012ES



LCR-8512ES

5. Cross Reference Guide

National	EAGLE-PICHER	GLOBE-UNION	ELPOWER	YUASA	POWER-SONIC (mainsupplier : GS)
LCR 6V1.2E				NP1.2–6	PS–612
LCR 6V3E	CF 6V2.6	GC 626	EP626–36	NP3–6	PS–626
LCR 6V4E				NP4–6	PS–640
LCR 6V4EL				NP4–6W	
LCR 6V6.5E	CF 6V5.5	GC 645	EP650–36	NP6–6	PS–660
LCR 6V8EA	CF 6V 8	GC 680	EP685–36	NP8–6	PS–685
LCR 6V10EA	CFM6V10			NP10–6	
LCR 12V1.9E	CF 12V1.5	GC 1215	EP1218–36	NP1.9–12	PS–1218
LCR 12V3EF	CF 12V2.6		EP1226–26	NP3–12	
LCR 12V6.5E	CF 12V5.5	GC 1245	EP1250–26	NP6–12	PS–1265
LCR 12V24E	CF 12V20	GC12230	EP12240–40	NP24–12B	PS–12200
LCL 12V 38E			EP12380–40	NP38–12	
LCR 12V60E					
LCR 12V80E					
LCR 12V100E					
LCR 12V120E					

(Note : all at 20°C, 68°F)

6. National Testing and Standards

6.1 Capacity

The discharge capacity is taken by discharging the battery at the discharge current under the ambient temperature as set forth in the specification. The charge before and after the above discharge must be carried out in the method indicated in the specification, or, if the charge/discharge conditions are not indicated in the specification, discharge the battery at 0.25CA up to 3.5V/4V, 5.25V/6V and 10.5V/12V battery.
In each case the discharging time must be no less than 180minutes. The charge will be performed under the conditions of 4.87V~5.00V/4V, 7.30~7.50V/6V and 14.6V~15.0V/12V battery (Maximum current: less than 2CA).

6.2 Cyclic Life Test

This test is carried out under the ambient temperature and the charge discharge conditions as required by the specification. In case the charge/discharge conditions are not set forth in the specification, the charge and discharge must be repeated under the ambient temperature at 25±2°C the resistance-load discharge equivalent to 0.25CA discharge (cut-off voltage of discharge: 3.5V/4V, 5.25V/6V, 10.5V/12V) for discharge, or 4.87~5.00V/4V, 7.30~7.50V/6V, 14.6V~15.0V/12V (max. current 0.4CA or less) for charge. **The cyclic life must be held at 50% of the initial discharge capacity and last for at least 150 cycles.**

6.3 Overcharge Test

The fully charged battery is overcharged in this test at the constant current of 0.1CA for 48 hours, and then stands for one hour.
Then the battery is continuously discharged at a constant current of 0.05CA until it discharges to an average of 1.75V per cell.
The appearance of tested battery after the test must be free of irregular conditions, and the capacity should be 95% or more of the nominal capacity.

6.4 Sealing Test

The following functions must be satisfied by the fully charged battery after it is overcharged for 48 consective hours at a 0.1CA current and for 24 consective hours at a 0.005CA current.

(a) Sealing Reaction Efficiency
The sealing reaction efficiency must be 90% or more of the quantity of electricity, which is converted by 25°C, 1 atm, per Ah.

(b) Safety Valve Function
The safety valve must be opened or closed without fail within the range of internal pressure of the battery from 0.01kg/cm² to 2kg/cm² (0.14 psi to 28.4 psi).

(c) Safety
The battery must be free of leaks and other defects.

6.5 Storage Test

The fully charged battery will be stored for 6 months under the temperature of 20±5°C; then discharged continuously at the constant current of 0.05CA upto the average cut-off voltage of discharge of 1.75V per cell. The capacity at this time must be 60% or more of the nominal capacity.

6.6 Vibration Test

A vibration of 1,000 times per minute at the full amplitude of 4mm will be applied on any side of the fully charged battery for 60min. Then check to see if the battery has endured against the vibration test without any broken parts or leaks, and its terminal voltage is held higher than the nominal voltage.

6.7 Shock Test

The fully charged battery will be dropped three times without applying any extra force **from 1 m high onto an oak board** (about 50mm thick). Then check to see if the battery has endured in the test without noticeable breakage or leaks, and its terminal voltage is held higher than the nominal voltage.

6.8 Other Tests

Other tests, if required by the specification, shall be conducted according to the instructions given in the specification.

7. Glossary of Terms

ACTIVE MATERIAL
The active electro-chemical materials used to manufacture positive and negative electrodes.

AMBIENT TEMPERATURE
The average temperature seen by the battery.

AMPERE-HOUR
Normally used to define capacity of the battery. It is the current in amperes, multiplied by the time in hours, during which current flows from the battery. Also expressed as milliampere-hours.

AVAILABLE CAPACITY
The capacity available from the battery based on its state of charge, rate of discharge, and ambient temperature.

BATTERY
Two or more cells, connected together, normally in series. At times, a single cell may be referred to as a battery.

C-RATE
A charge or discharge current rate, expressed in amperes or milliamperes. It is numerically the same as the rated capacity of a battery expressed in ampere-hours.

CAPACITY
The electrical energy available from a cell or battery expressed in ampere-hours. It refers to the discharge of a constant current for a measured time to a specified cutoff voltage (normally 1.75V per cell), at a specified temperature.

CAPACITY FADE
Loss of capacity from inadequate recharging.

CELL
A minimum unit of battery that composes a storage battery; the nominal voltage of a cell of the lead-acid battery is 2.0V.

CELL REVERSAL
The polarity of cell voltage is inverted when the battery is forced to discharge. Note that the service life of battery is shortened by the polarity inversion.

CHARGE
The process of restoring electrical energy to a cell or battery.

CHARGE ACCEPTANCE
Expresses the degree to which the amount of electric charge is effectively accumulated within the battery.

CHARGE EFFICIENCY
Expresses the degree of efficiency of accumulation of charge electricity within the battery.

CHARGE RETENTION
Capacity is gradually lost during storage. Charge retention indicates the percentage of the capacity still remaining

CLOSED CIRCUIT VOLTAGE TEST
A test method in which the battery is briefly discharged at a constant current, and the voltage is measured.

CONSTANT VOLTAGE CHARGE
A method of charging the battery by applying a fixed voltage, and allowing variations in the current. Normally used for sealed lead acid batteries. Also called constant potential charge.

CONSTANT CURRENT CHARGE
A method of charging the battery using a current having little variation. Normally used for sealed Ni-Cd batteries.

CUTOFF VOLTAGE
The final voltage of a cell or battery at the end of charge or discharge.

CYCLE
A single charge and discharge of a cell or battery.

CYCLE LIFE
The number of cycles a cell or battery provides before failure.

CYCLIC USE
A method of using a secondary battery repeatedly by charging and discharging.

DEEP DISCHARGE
The discharge of a cell or battery to 80~100% of its rated capacity.

DEPTH OF DISCHARGE
Frequently expressed as a percentage, it is the amount of capacity removed from a cell or battery during discharge.

DISCHARGE

The function of removing current from a cell or battery.

DISCHARGE RATE

Normally expressed as fraction of C. It is the rate at which current is taken from a cell or battery.

DISCHARGE VOLTAGE

The closed circuit voltage of a battery during discharge.

DUTY CYCLE

The normal use of the battery in its application, includes charge, discharge, and rest intervals.

END-OF-CHARGE VOLTAGE

The voltage reached by the cell or battery at the end-of-charge, while the charger is still attached.

END-OF-DISCHARGE VOLTAGE

The final voltage of the cell or battery while the load is still attached.

ELECTRODE

The positive or negative plate holding the active materials in the cell.

ELECTROLYTE

Conducts ions in the cell. Lead-acid batteries use sulfulic acid solution.

ENERGY DENSITY

Ratio of cell or battery energy to weight on volume: watt-hours per pound or per cubic inch.

FAILURE MODE

The manner in which a cell fails to function.

FLOAT

Maintains full capacity in a cell or battery by applying a continuous charge. In this instance, the load is connected to the battery and current is provided from the charger.

GAS ABSORPTION

The ability of the negative plate to absorb oxygen gas generated within the battery; the greater this ability, the greater the current that can be used for charging.

HIGH-RATE DISCHARGE

A very rapid discharge of the battery. Normally in multiples of C.

INTERNAL IMPEDANCE

The resistive value of the battery to an AC current, expressed in ohms. Normally measured at 1,000 Hz at full charge.

INTERNAL PRESSURE

The pressure within a sealed battery; oxygen is generated from the positive plate at the end of charging, causing internal pressure to increase.

INTERNAL RESISTANCE

The resistance within the battery; an element which generates a voltage drop almost proportional to current.

LIFE

The time period until the battery can no longer be used because it has lost its characteristics. (See: Failure Mode.)

LOW-VOLTAGE CUTOFF

A sensor designed to end discharge at a predetermined voltage level.

MAINTENANCE-FREE

Secondary cells which are not sealed require periodic addition of water. Sealed lead-acid batteries do not require such maintenance, and therefore are "maintenance free".

MEMORY EFFECT

A reversible failure, occasionally seen, due to repeated shallow discharges. Memory effect is virtually nonexistent in Panasonic batteries.

NOMINAL VOLTAGE

A nominal value to be used to indicate the battery voltage; for the sealed-type lead-acid battery; its nominal voltage is 2.0 volts per cell.

NOMINAL CAPACITY

A nominal value to be used to indicate the battery capacity; for the sealed-type lead-acid battery, its nominal capacity is the value measured at the 20-hour rate.

NON-CONTROLLED CHARGE CURRENT

A charge current which can be maintained continuously, regardless of the state of charge of the cell. Varies with battery size.

OPEN-CIRCUIT VOLTAGE

The measured voltage of the cell or battery without a load attached.

OVERCHARGE

The continuous charging of a cell after it achieves 100% of capacity. The battery life is reduced by prolonged over charge.

OVERCHARGE CURRENT

The charge current supplied during overcharge. Batteries can accept continuous overcharge at recommended rates and temperatures.

PRIMARY CELL

A cell which can be discharged only once. Example: Manganese-zinc cells, lithium cells.

RATED CAPACITY

The manufacturer's rated capacity of the cell. Panasonic batteries are rated at C/20°C. (See: Capacity)

RESEALABLE SAFETY VENT

The resealable safety device built into the cell to release excess pressure and prevent rupture.

SECONDARY BATTERY

A battery which can be charged and discharged repeatedly Example: Lead-acid batteries, nickel-cadmium batteries.

SELF-DISCHARGE

The loss of capacity by a battery while in the stored or unused condition. The rate of self-discharge is affected by ambient temperature.

SEPARATOR

The material separating the electrodes. Used to hold the electrolytes. Normally glass fiber is used.

SHELF LIFE

The life of a battery when stored in the unused condition. Panasonic batteries can be stored for extended periods of time before use or reuse.

SLA BATTERY

The SLA battery is a sealed lead-acid battery. It does not need to have water added during its whole service life. All LCR batteries are SLA batteries. (See maintenance Free).

STAND-BY USE

A method of using secondary batteries in which the battery is constantly charged so that it is always ready for use.

STANDARD CHARGE

The normal charge rate used to charge a battery in 14~16 hours.

STATE-OF-CHARGE

Expressed as a percentage of C, it is the available capacity of a battery at a given time.

TAB

Also called a lug. Used to connect batteries together or as a terminal for connection to equipment.

UNDERVOLTAGE CUTOFF

A sensor which cuts off discharge in order to prevent cell reversal when the battery falls below preset cut-off voltage.

VOLTAGE CUTOFF

A sensor used to terminate a charge or discharge when the battery voltage reaches a predetermined level.